NOV 1 1 1925

Engineering News-Record

Devoted to Civil Engineering and Contracting. McGraw-Hill Company, Inc.

November 5, 1925

Beginning a series of articles on

SOIL MECHANICS

By Charles Terzaghi

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First article in this issue

Phenomena of Cohesion of Clay

Other articles in this issue:

Snow Drift Prevention and Control on Highways

Grouting the Rock Surrounding the Oak Grove Surge Chamber

A Concrete Arch Bridge of Unusual Form and Details

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Engineering in The Small City: The Editor Visits Madison, Wis.

Engineering News-Record Statistics of the Construction Industry

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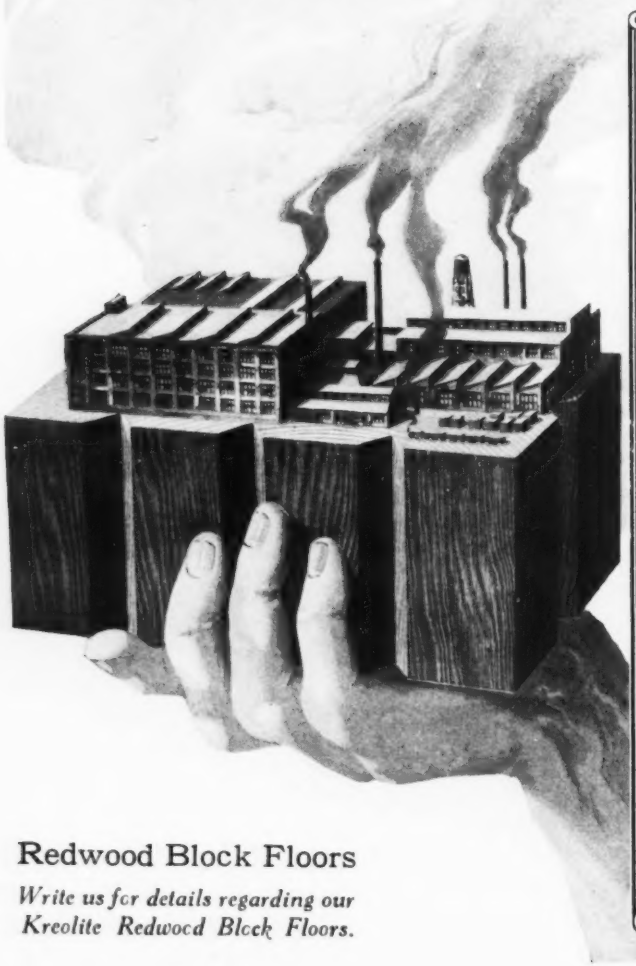

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DEVOTED TO CIVIL ENGINEERING AND CONTRACTING

FRANK C. WIGHT
Editor

Volume 95 NEW YORK, NOVEMBER 5, 1925 Number 19

Practical Demonstration

IT ALMOST looks as though the League of Nations had staged the Greek-Bulgarian gestures toward war solely for the purpose of calling the affair off and thereby demonstrating to skeptical nations the power there lies behind the League. Anything in the Balkans always partakes of opera bouffe but this generation cannot forget that the greatest war of all started there by just such a spark as the one now happily extinguished —for a time at least. A few more such demonstrations and the assurance that fairly permanent settlements have been made will cause a lot of Americans to wonder how long this country can continue to refuse to participate in the attempts toward co-operative management of world affairs.

Belittling Engineering in New York State

IN TUESDAY'S election New York State voted for an amendment to its constitution which requires that the coming legislature enact statutes reorganizing the state departments. Generally speaking the proposed reorganization is desirable, particularly as it makes appointive some special offices which have hitherto been elective. In one thing, however, the amendment is not sufficiently definite and it will remain for the legislature to make amends. This is in the matter of the state engineer's office. Hitherto that official has been elected, and by law had to be an engineer. In the new system there is no such official provided but there is a department of public works, together with nineteen other departments, including architecture. It is imperative, therefore, that the legislature make sure that the head of the department of public works, which must have to do only with engineering, should be an engineer. That at least will be necessary to clear up the obvious incongruity of having a department of public works, with engineering as a subordinate function, and of having a co-ordinate department of architecture.

Apprenticeship Grows

IN THE New York building trades in less than four years the number of apprentices has doubled and trebled. Indeed this is an inadequate comparison for in some trades in 1922 apprenticeship did not exist in any real sense. But it is not in comparative figures that the true significance of the changed conditions lie. The impulse to bring up trained workmen has been begotten in the employers of labor, in the organizations of skilled workmen and in the direction of the public and vocational schools of the city. And of superior importance, the spirit to advance artisanship has grown greater among the organized workers themselves than in any of the other interests concerned. There are now 4,325 apprentices in training in the building trades in New York. At present there are school facilities for only 2,452 of all, but, it is stated, the coming year will see the deficiency made up. It has required money to put young men to school in carpentry, masonry, painting, and the mechanical trades and here again organized labor has contributed its full share or a little more. The final point to be noted is that this change of four years is the result of organized effort by the Apprenticeship Commission of the New York Building Congress in which the professional architect, the building contractor and the building trades worker are represented and are working shoulder to shoulder.

A.S.M.I. Prospects

ENGINEERING societies are so numerous that each one must prove its necessity to get support today. For some years past it has been evident that the American Society for Municipal Improvements was neither so active or so appealing as to warrant much optimism as to its future. Its field, however, is so important and its opportunity for service to that field so great, that the signs of rejuvenation at the recent meeting at Des Moines are most welcome. Municipal engineering is growing in volume, scope and importance to the community. There is no reason why the A. S. M. I., if properly directed, should not survive as a fit engineering society.

Street Resurfacing

RESURFACING old streets is an economic necessity which confronts all American cities and street engineers have before them more insistently than any task of new pavement design the problem of developing suitable practices in resurfacing. Resurfacing has come to stay as a major operation in street upkeep. There is no contention that by it as good a street is secured as by new construction but the lesser improvement has strong reasons in its favor. It is comparatively cheap. Therefore it gives mileage and it gives it quickly. It does not change things as they are; street grades, curbs, sidewalks, entrances are not disturbed. The property owner is quick to grasp these gains and prompt to approve resurfacing where new construction would raise his opposition. He will accept the perpetuation of old faults; he may even realize that new paving is postponed at most only for a decade but he will argue that in ten years engineers will be building pavements better and perhaps prices may be cheaper and anyway he may sell his property before ten years and the new owner will have to pay for new construction. Indeed there are found many and sound arguments for resurfacing. The practice is increasing. Engineers have to develop the technique—materials, plant, methods, and economics. It is for this reason that the symposium of articles on asphalt resurfacing in this issue is important. Each is a relation of a practice which has proved successful. Indications of costs are given. Widely separated localities are represented. There is evidence in fact which commands respectful consideration.

A Science of Soil Action

NOWHERE does the civil engineer encounter so many baffling problems as in connection with earthwork, his largest activity. Clay and sand in particular give him endless trouble, mainly because he knows little about them. When he excavates, when he builds dams or embankments, constructs foundations or digs tunnels, he is each moment working at the verge of engineering knowledge. Land slips and caving banks give him frequent reminders of his inability to foretell or prevent destructive soil action. This applies also to foundation settlement, which almost daily supplies an indictment of his ignorance of soils.

The need for developing such knowledge has been felt by many. That soils, representing the oldest constructive material, had no science of stresses, no mechanics other than the granular theory of the Coulomb-Rankine time, has long been recognized as a serious lack. But it has been widely believed that soil action is subject to so many erratic influences as to make a science hardly possible. This view is now proved wrong. A brilliant series of articles, the first of which we publish in this issue, shows that the behavior of clays and sands is just as definite, just as constant and subject to calculation and analysis, as the behavior of a piece of steel or concrete under load. The articles present a new science in embryo, the science of soil action. They establish convincingly that future engineering in the field of soils will be built up on the substratum of the facts here developed.

As so far worked out, the new knowledge relates to the physical behavior of sand and clay. In its further extension, no doubt, other soils also will be covered. Even in its present form, however, it is of far-reaching value to the practical man.

The background of these articles is interesting. Six or seven years ago Charles Terzaghi, an engineering teacher in Constantinople, began some laboratory experiments on sand to discover the nature and laws of its internal friction and volume changes under load and moisture. He found the task exasperatingly slow, but persevered with patience and originality, in spite of having to depend on improvised apparatus of most simple kind, and in time obtained a wholly new picture of the phenomena of sand behavior. Some of the results which that early work yielded appeared in an article published in *Engineering News-Record*, five years ago (Sept. 30, 1920). Subsequently he extended his work very greatly, and in particular made searching studies of clay. Last year the work reached a stage where its results began to group themselves into a full and highly enlightening explanation of how both plastic and granular soils behave.

The series of articles now beginning represents a somewhat sketchy outline of the principal facts so far developed.

Most interesting of the facts in the entire series, and most immediately fruitful, are those which relate to clay, brought out in the opening articles. They explain why clay coheres, why it compresses greatly under load and shrinks on drying, and why sand and clay differ. They help us also toward an understanding of what happens when a soil breaks down into a semi-liquid state, a phenomenon involved in many of those instabilities of soil that give constructors trouble and consume labor and expense.

Not all soils are clays and sands. Soils of mixed grain texture or structure are fully as important and only a first step will have been made until the facts concerning these soils also are developed. Very much further investigation needs to be made to survey the whole field that Dr. Terzaghi has reconnoitered and successfully outlined.

A great deal also remains to be done in bringing the new facts and teachings to bear upon the problems of practice with least delay. Such utilization can be brought about only through an educational process of large proportions. The present articles represent one initial stage of the process. Fortunately, Massachusetts Institute of Technology has taken up an active share of the educational work, by engaging Dr. Terzaghi to come to this country and make his work and results available to students. This enterprising action gives promise of soon making the young science an integral part of our current engineering knowledge.

Because much work remains to be done in exploring the field of soil phenomena, there is a call for the assistance of many trained investigators. It is desirable that full development of the field come about as early as possible, and it may be hoped that the present series of articles will not only bring enlightenment and practical help to the working engineer, but will also inspire laboratory investigators to co-operate in advancing our soil knowledge still further.

Shall We Limit Federal Aid to Roads?

NINE years ago, after some years of deliberation, Congress committed the country to a new policy of road building and financing. On account of the war, it had little effect until 1921, when a revision into what is practically the present law was made. Under that law the federal government obligated itself to pay up to an amount of $15,000 per mile, but not more than on a fifty-fifty basis, for certain roads which the state built. These roads had to be agreed upon between the state and the nation, had to form part of a nation-wide system of roads now completely laid out on paper, could not comprise more, except in special cases, than 7 per cent of the total mileage of the roads within the state, and had to consist at least three-sevenths of primary roads and four-sevenths of so-called secondary roads by mileage, and not more than 60 per cent of the total funds could be expended on through primary roads. Apportionments were made to the separate states on an average basis of area, population, and post-road mileage.

Under this law the nation, up to Oct. 1 of this year, had spent nearly $400,000,000 on roads, costing a total of $900,000,000, the remaining half billion being paid by the states. This totaled around 51,000 linear miles of highway.

Since 1921 the law has been increasingly effective in its operations. It took some time for the mechanism to become well oiled, but with minor exceptions procedure now is excellent and both the states and the federal government are well satisfied with the progress made. Up to quite recently the prospects have been that the law was fixed at least until a fair proportion of the needed highways of the country were built and that the federal government would continue to aid the states and continue at the same time to develop the technique of road building. But the law now has run afoul of political developments which threaten to destroy it.

These are the days of economies in public expenditure, especially at Washington. The Coolidge administration has achieved an outstanding popularity through its insistence on economy in governmental affairs. The average citizen does not stop to inquire whether this insistence has resulted in proper or improper reduction of public expenditures. His only feeling at the present time is that taxes are too high, that most government operations are unnecessary, that all government employees are loafers, and that anything that can be done to reduce congressional appropriations is a wise move. So we find the "official spokesman" of the White House announcing last week that federal highway appropriations must be kept "within reasonable bounds," that the President is opposed to the fifty-fifty division of expenses and believes such expenditures as are made should be confined to important through roads. The "official spokesman" further gives out that the President is said to be of the opinion that the use of federal money in road building is stretching the postal clause of the Constitution.

Certain of the state governors, too, are agitating against the federal-aid law. They see in road aid one more step in the insidious encroachment of the nation upon the powers and privileges of the state. These governors add to the economy plea the argument more appealing to their own constituents, that their respective states are paying into the national government much more than they are getting back in the way of road aid, that the weaker states are having their roads built, in effect, by their more prosperous sisters.

Just what does this federal aid mean? About one billion dollars a year is being spent in roads and streets in this country. Of this the federal government contributes about seven per cent. What do the people get for their seven per cent?

The law has been the direct cause of a reorganization of most of our state highway departments, of the organization of some departments in states where they did not exist, and of the general uplifting of the personnel and technique of the departments in each of the states. It has encouraged the construction of through routes, which has a certain significance in carrying out the postal requirements of the Constitution, but a greater significance in making the highway system national rather than local, an obvious necessity in these days of incessant touring from state to state. It has helped toward the standardization of construction. It is beginning to be effective in standardizing the marking and signaling systems. It has resulted in research of inestimable value to the road builder, and it has encouraged further research by other agencies. It has made possible a co-ordination of road-building efforts in this country never attempted before.

Against this what can be set? It has encouraged paternalism by setting up one more thing for the government at Washington to do, but in so doing it has interfered only slightly with states rights and has increased rather than decreased state obligations. It has undoubtedly stimulated the construction of roads and has led to what some might call an orgy of road building. Whether or not that is a good thing is a matter for argument, but that argument must be made on economic grounds, for no one can assert that more roads are not needed. It has increased federal expenditure, but only as a drop in the great bucket and that drop has gone toward constructive effort, toward the upbuilding of what in private business would be called capital account. It has disproportionately benefited some states, but by no means to the degree statistics would tend to show, for a state's contribution to federal taxes is not a direct gage of the contribution of the citizens and corporations of that state; the Southern Pacific and Union Pacific railroads, whose lines do not extend east of the Mississippi, pay some nine million dollars as a part of New York's contribution to the national treasury. It has presented some difficulties in operation in the way of too great control in Washington or by deputies, but this has only offset the unreasonable demands of some of the states that they be granted the federal-aid money and full control of that money besides.

The evils of the law lie more in the degree of its application than in its principle. Too much federal aid might conceivably foster that over centralization and paternalism that has been growing overfast since the war. But just enough is required by the highway needs of the country. After all this is one nation, not merely an aggregation of states. The automobile has made it imperative that the states be tied together by a system of highways. Co-operation between the states is possible, but it is going to be made more active by a federal urge that is going to be felt by the states only if they can participate in some degree in the expenditure of federal funds. Some of the states are quite competent in themselves to carry on their own state highway work. Some of the states, unfortunately, are not. It would not be possible for the government to step in and to interfere in the construction of roads inside a state without participation in the cost of the roads, and it would not be possible for it to spend its money in one of the states without spending it in another. Further than that, it is highly desirable that there be a co-ordinating influence in the kinds of roads that are built, in the marking of the roads, in the development of routes, an influence which again would not be effective without financial aid and the control that such financial aid gives.

Just how much money is going to be required to bring about this desirable co-ordinating influence it is difficult to say. Certainly, it could not be done with the few hundred thousand dollars a year that the Office of Public Roads had to be satisfied with when it was merely an investigatory and publicity body. Probably it is not going to be necessary to continue to appropriate $100,000,000 a year for all time for this purpose. There is a limit to which the federal government should go in providing local facilities. But there has been laid out a system of highways, a system which up until quite recently has been approved by everybody who has made a study of it. That system is only partly completed. Until it is completed it would seem to serve the best interests of the nation and of the states to have the participation in the cost of its construction carried on in the manner in which it has been so successfully carried on during the past five years.

The time may come when it will be desirable to reduce this appropriation, to throw back on the states themselves all of the responsibilities for road construction, but that time will not be here until the states have as a whole developed a much more sound control of their highway system and until the leading roads of the nation have more nearly approached the total that there should now be.

Principles of Soil Mechanics: I—Phenomena of Cohesion of Clay

Relation Between Load and Moisture-Content—Hydrostatic Stress in Clay—Shrinkage and Negative Hydrostatic Pressure—Surface Tension the Cause of Cohesion

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This article begins a series in which the nature and behavior of soil are studied and analyzed, with fruitful results. The first four articles discuss clay, explaining its cohesion, shrinkage, elastic behavior and settlement. Later, sand is taken up, and the characteristics of sand and clay are compared. Mixed soils are not dealt with; nevertheless the facts developed in the author's investigation bear intimately on problems arising in practical engineering work wherever clay or sand soils are concerned.—Editor.

A NUMBER of years ago the author became impressed with the perplexing character of the problems which the behavior of sand and clay soils presents to the engineer. It was evident that our knowledge of the underlying laws of action of these materials is not sufficient for proper solution of these problems, and that the first step of progress would be a careful experimental study of their physical behavior. At Robert College the author at last found opportunity to carry on such a study, which began with sands and later took up clays. The work has yielded results of interest and (it is believed) importance. Some of the early results of the study of sands were reported in *Engineering News-Record*, Sept. 30, 1920, pp. 632-637. A fuller statement of results is now possible, as the later investigations included clays, the physical properties of which had remained essentially unexplored. The term clay indicates mixed-grained, plastic soils consisting of particles from 1 mm. down to 0.006 mm. in diameter and a very small percentage of "ultra-clay" (colloidal particles in the colloid-chemical sense of the word). Hence the term includes almost all the soils which are commonly known as "clays."

Prime factors in the behavior of clay are (1) cohesion, (2) the action of the moisture contained in the clay, and (3) permeability. The present and several succeeding articles will summarize the facts concerning them as developed by the experimental investigation. Cohesion will be considered first.

Cohesion is commonly looked on as a characteristic property of certain soils. No serious attempt has thus far been made to analyze the physical causes of the property, but it has apparently been accepted as an elementary fact, unsuitable for further analysis. As a consequence the mechanics of clays has remained in a rudimentary state. We know practically nothing about the part played by the factors of time and permeability in the processes called "settlement," nor have we any clear conception of what causes the swelling of clays. Under these circumstances it is timely to investigate these phenomena systematically. The author has carried out a long series of laboratory studies in this effort.

Load and Moisture Content—The simplest process a layer of clay can undergo is compression under a uniformly distributed load when the layer is restrained from expanding laterally and when surface tension of the capillary water is excluded. In order to accomplish the latter, the author's experiments were made with a mixture of clay and water (free from air), and during the experiments the surface of the clay was kept covered with water; thus there was no external force acting on the clay particles except the surcharge. As the voids of the clay are completely filled with water, a certain quantity of the capillary water must escape during the compression of the clay by the surcharge.

The experiment was made as follows: The lower part of a glass cylinder (Fig. 1) was filled with a liquid but very viscous mixture of clay and water. The bottom of the cylinder was covered with a sheet of thin filter paper (not shown), and on this rested a bronze ring completely surrounded by and immersed in the clay solution. The surface of the mixture was covered with a layer of filter-paper, and on top of the paper was placed a filter composed of quartz sand of grain size $\frac{1}{4}$ to $\frac{1}{2}$ mm. Within 24 hr. the compression produced by the weight of the filter was completed, and the filter was then loaded by a brass cup. One day later further load was added by filling the lower half of the cup with lead shot, and after the lapse of two more days the upper half of it was filled too (total load at this time 0.1 kg./cm.^{2}). For measuring the compression produced by the load, the side of the brass cup was provided with a scale. Additional surcharge was applied by means of a lever bearing on the cup through a steel ball. Thus the pressure was increased at about two-day intervals from 0.1 to 0.2, 0.3, 0.6 and 1.2 kg./cm.^{2}

Higher pressures were applied in a testing machine. For this purpose, the lever, cup and sand filter were removed, the bottom plate of the cylinder unscrewed, and the clay forced out by a piston. Then the ring was freed from the surrounding clay in such a manner that it contained a layer of clay of thickness equal to the height of the ring (1 cm.). A sample of the removed part of the clay served for determining its water content. The ring with its clay core was weighed, and then the experiment was continued by means of the apparatus Fig. 2. The change from one apparatus to the other was made rapidly, to minimize loss of water by evaporation.

The apparatus consisted of a square vessel the bottom of which was covered with two layers of thick and one layer of fine filter paper, two superimposed bronze rings, bronze loading plates, and a steel ball. The two rings fitted together with a ground conical joint. First the lower ring with its content was placed on a moist sheet of thin filter paper, the upper ring was applied and lined with filter paper (see detail in Fig. 2), the

upper surface of the clay was covered with a circular piece of moistened filter paper, a sand filter was applied, and finally the whole set with the bronze plates and ball was transferred into the enclosing vessel, which was filled with water and placed in a testing machine.

In the machine the pressure was raised within twenty minutes from zero to 2 kg./cm.² and then left constant. Under this pressure the thickness of the

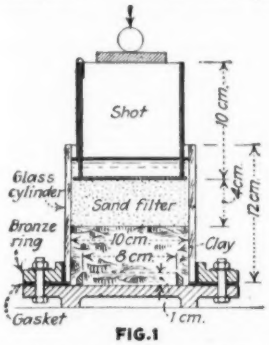

FIG. 1

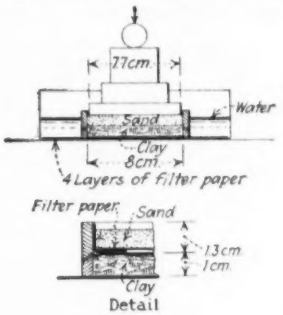

FIG. 2

FIGS. 1 AND 2—DETERMINING RELATION BETWEEN PRESSURE AND MOISTURE-CONTENT OF CLAY
Fig. 1—Low-pressure tests. Fig. 2—High-pressure tests.

layer decreased, at first rapidly and then more slowly, and within about two days became constant, indicating hydrostatic equilibrium. Now the water was siphoned out of the vessel, the piston was rapidly lifted, the bronze plates and the filter and upper ring were removed, the upper surface of the clay was carefully dried off by means of absorbent paper, the weight of the ring together with its content was determined, the clay particles projecting beyond the upper edge of the ring were scraped away, and the weight was determined once more. Operations performed, the set was reassembled and the experiment was continued.

Thus the pressure was raised at intervals of about two days, from zero to 2, 4, 8, 14 and 20 kg./cm.². The measurements furnished the data for computing the co-ordinates of corresponding points of the pressure-moisture curve. Then followed a complete cycle, in which the pressure was successively kept constant for two days at the following values: 8, 4, 2, 1, 0 (four to six days, to allow complete resaturation), 1, 2, 5, 10 and 20 kg. per cm.²

At the outset of the investigation the author feared that the total removal of the pressure in each of the consecutive steps of the test might represent an important source of errors of observation. As a matter of fact no results at all could be obtained by such method in investigating the compressibility of sands or of other highly permeable granular materials. But in the case of clay experience has shown that the fear was not justified. Due to low degree of permeability even of sandy clays the effect of resaturation is negligible. Thus, a layer of clay 1 cm. thick and carrying no surcharge at all was brought into contact with water, after it had been previously compressed by a load of 18.9 kg./cm.², and in an hour its moisture content increased only 0.15 per cent, while the time during which the clay has a chance to take up water between two consecutive tests never exceeds two minutes.

After having completed the cycle, the ring with its clay core was weighed once more. Then a sample of the clay was set apart for determining the final moisture content of the layer. The figure thus obtained served as a basis for calculating the moisture content which corresponds to the successive stages of the experiment. The initial moisture content (corresponding to a pressure of 1.2 kg. per sq.cm.) being known, the results of the calculation could be checked by theoretically calculating the subsequent moisture content. Any difference between the actual and the theoretical moisture content (in no case large) was then distributed over the intermediate values.

Fig. 3 shows typical results. Abscissas represent intensity of loading and ordinates moisture content in percentage of the space occupied by the solid matter of the clay. A yellow pottery clay and a blue marine clay are represented in the lower diagram, and a gray sandy delta mud in the upper. Each test lasted about eight weeks. The main branch of each curve portrays the effect of gradually increasing load (combined compression), while loading cycles are represented by curved hysteresis loops (elastic expansion).

Lag of Compression—As already mentioned, the compression produced by the application of a load never occurred at once, but increased for some time while the load remained constant. Equilibrium was never reached in less than about 24 hr., in spite of the fact that the layers were very thin. This fact is very significant; it indicates that the capillary water took time to drain from the interior of the clay towards the free surfaces and escape through the filters. Since this flow of water implies a hydrostatic head, and the surface of the clay (being covered with water) was constantly at zero hydrostatic pressure, the application of the load must have produced a positive hydrostatic pressure in the capillary water of the central parts of the clay. The *hydrostatic stress difference* which produces the outflow of the capillary water is consumed by the resistance which the water encounters in the narrow voids of the clay on its way to the surface.

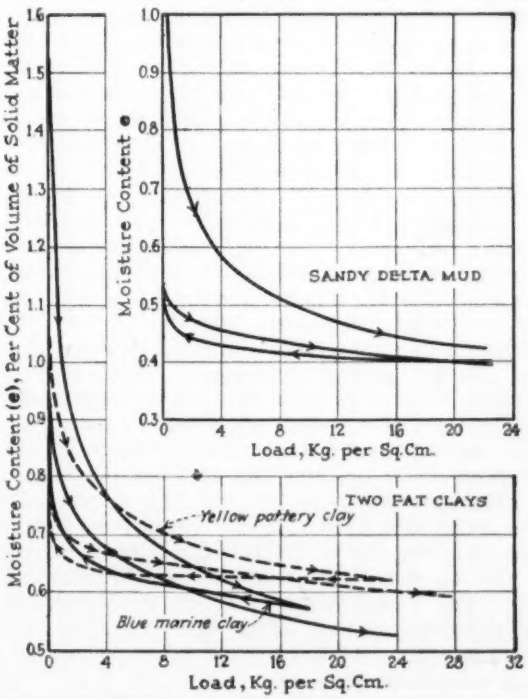
Moisture Content (e), Per Cent of Volume of Solid Matter
Moisture Content e
SANDY DELTA MUD
Load, Kg. per Sq.Cm.
TWO FAT CLAYS
Yellow pottery clay
Blue marine clay
Load, Kg. per Sq.Cm.

FIG. 3—PRESSURE-MOISTURE CURVES FOR THREE CLAYS

The author later proved by other experiments (see a subsequent article) that the flow of water through clay follows Darcy's law as closely as does the flow of water through sand. Hence there exists simple proportionality between the value of the hydrostatic stress difference and the amount that the thickness of the layer decreases per unit of time at constant surcharge, because the decrease of clay volume is identical with the volume of the water that escapes through the surface of the clay. Immediately after the load is applied the speed with which the clay volume decreases is greatest, hence the hydrostatic stress difference must be a maximum; in the final state the hydrostatic pressure has become zero in every part of the layer and the thickness of the layer remains constant (hydrostatic equilibrium of the clay).

From the results of the tests described we learn that pressure and moisture content of a clay are as definitely related as stress and strain in solid bodies. The only difference between the two relations is that the compression of the clay develops gradually, while the application of a pressure on a solid body is almost immediately followed by the corresponding strain. In addition we have learned that a change of the volume occupied by a mixture of clay and water involves a flow of capillary water from the central parts of the clay towards the surface, which in turn requires the presence of a hydrostatic stress difference. The strain does not become constant until the hydrostatic stress difference has disappeared.

Shrinkage Test—Keeping these simple but important facts in mind, we may proceed to a second series of tests. We fill the glass cylinder of Fig. 1 with a liquid yet very viscous mixture of clay and water, just as was done before. But instead of covering the surface of the clay with a filter and loading it, we leave it as it is, in contact with the atmosphere. Precisely the same phenomenon occurs without load which we previously produced by means of loading the clay surface: the capillary water flows from the central part of the clay towards the surface, where it evaporates; the moisture content of the clay becomes smaller and the thickness of the layer decreases. *The clay shrinks.*

The only difference between the artificial compression and the natural shrinkage is that compression under load can be carried as far as we want, while in shrinkage due to evaporation a point is reached beyond which the volume of the clay remains constant. At this shrinkage limit the clay passes from the semi-solid into the solid state. Before the limit is reached, the layer shows symptoms of lateral contraction; it shrinks away from the ring to which it is confined, and cracks. At the shrinkage limit the clay usually changes its color. Yet, from the outset of the shrinkage test to a point beyond the limit of the plastic state, the process of compression and the process of shrinkage are in every respect identical.

It is astonishing that nobody seems to have felt the necessity of investigating the physical causes of this identity. As a matter of fact, analysis of the phenomenon leads to new and very important conclusions. In order to perform it we have merely to keep in mind that the elementary laws of mechanics which apply to solids and liquids in general are valid also for the constituents of a mixture of clay and water.

Negative Hydrostatic Pressure—By direct measurement it was found that the water content of a layer of clay slowly shrinking at normal temperature remains fairly uniform throughout the thickness of the layer, if this thickness amounts to not more than a few centimeters. Hence there must be a continuous flow of water from the interior of the layer towards the surface of evaporation. The flow indicates the presence of a hydrostatic stress difference between the interior and the surface.

During the loading test the hydrostatic pressure acting in the central part of the layer of clay was positive. This positive hydrostatic pressure was balanced by the external load pressing upon the particles between which the capillary water flowed toward the free surface. During the shrinkage test the external load was zero, and as the dead weight of the clay can be considered negligible compared with the intensity of the forces we have to deal with, the hydrostatic pressure in the interior of the clay is zero. But as the flow of the capillary water toward the surface of evaporation requires the existence of a hydrostatic stress difference, the hydrostatic pressure acting in the vicinity of the surface of evaporation must have been negative.

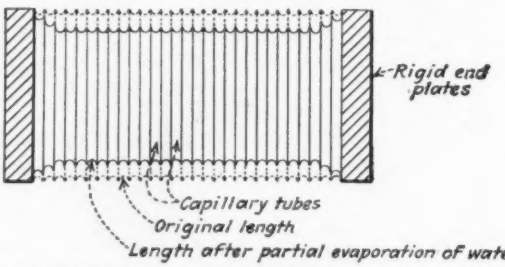

FIG. 4—BUNDLE OF CAPILLARY TUBES COMPRESSED BY EVAPORATION OF CONTAINED WATER

During the compression test, surface tension of the water was not active, because the free surfaces of the clay were covered with water; only the external load forced the clay particles down. During the shrinkage test, there was no external load, but surface tension acted all over the top surface of the clay. Therefore the hydrostatic stress difference and the negative hydrostatic pressure could not be produced by other than the surface tension of the capillary water.

In a vertical capillary, water may rise to great height. The surface tension at its surface, amounting to T dynes per centimeter of circumference, exerts a lifting force of $\pi dT/g$, where d is the diameter of the capillary in centimeters and g is the acceleration of gravity in cm./sec.^{2}. Equating this force to the weight of the column of water in the capillary, of height h cm. and specific gravity w, we obtain $h = 4T/wdg$. The lifting force at the surface carries the weight of the column by a tensile stress in the water column, as water has no shearing strength. This tension, or negative hydrostatic pressure, has its maximum amount hw just under the upper surface of the column, and at any other point, at height h' above the level of water in the vessel below, it has the value $h'w$. Precisely similar tension, or negative pressure, exists in the clay during its shrinkage, and explains the phenomena which occur during the drying process.

A layer of clay surrounded by a stiff ring represents a bundle of capillary tubes whose ends are located within the free surfaces of the layer (Fig. 4). At the outset the tubes are filled with water. Evaporation at the free surface tends to cause the water to retire into

the interior, but it is prevented from doing so by the same forces which drive the water up a capillary, and therefore it continues to occupy the whole void space within the clay. The volume of the water decreasing by evaporation, the clay is compressed by the surface tension of the water; in other words it shrinks, and at the same time the water comes under tension.

The analogy between compression by load and shrinkage by evaporation is set forth diagrammatically in Fig. 5. The direction of water flow and the nature of the internal pressures are indicated.

The intensity of the forces increases in direct proportion to the quantity of water evaporated, provided the solid matter follows Hooke's law. They reach their maxima when the full capillary force of the water is developed (*hw*, above); this marks the shrinkage

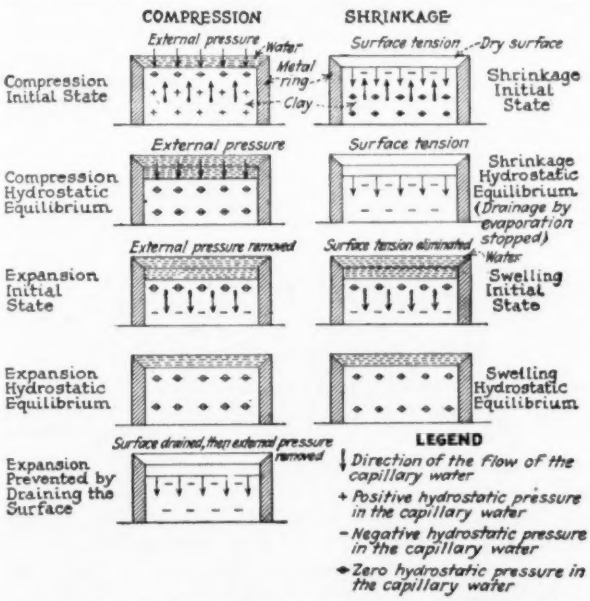

FIG. 5—DIAGRAMMATIC COMPARISON OF COMPRESSION AND SHRINKAGE OF CLAY

limit. Further evaporation causes the water to retire into the interior of the bundle, and the free surfaces change from dark to light color.

The pressure exerted by the surface tension will be called the *capillary pressure*, and its maximum value the *transition pressure*, which is the limit at which the clay passes from the semi-solid to the solid state. It has been proved that capillary action involves a tension in the capillary water equal to the capillary pressure. This tension cannot possibly be greater than the "intrinsic pressure" of the water. However, since the intrinsic pressure of water amounts to about 21,000 atmospheres, the transition pressure is limited only by the size of the voids of the clay.

The intensity of the negative hydrostatic pressure is evidently identical with the intensity of the external pressure required to produce the same degree of compression as the one brought forth by shrinkage. Owing to this fact, the transition pressure may be determined from the moisture content at which the clay ceases to shrink (shrinkage limit) and the external pressure required to reduce the moisture content of the clay from its initial value down to that at the shrinkage limit. Following this method, the author has found the transition pressure of a yellow, residual clay to be 171 kg./cm.² (cube compressive strength 52 kg./cm.²), and that of a blue, marine clay to be 339 kg./cm.² (compressive strength 86 kg./cm.²). Thus the capillary pressure may be a force of enormous intensity. Yet the very existence of this force has never been suspected up to this time.

Swelling of Clay—If the free surface of a layer of plastic or of semi-solid clay is covered with water, the surface tension at once becomes zero and the clay expands. This swelling is identical with the expansion of the clay produced by the removal of an external load (recurrent branches of the hysteresis loops in Fig. 3), and represents elastic expansion of the clay caused by the elimination of the surface tension of the capillary water. Since the increase in bulk means increase of water content, it is apparent that water enters through the free surface and flows into the interior, impelled by the hydrostatic stress difference between the surface (where the pressure is zero, since the surface is covered with water) and the interior (where negative hydrostatic pressure exists).

If, during a compression test, one drains the water completely off the surface and then removes the external load, the volume of the clay remains nevertheless unchanged, because expansion would mean increase of the moisture content and there is no free water available. On the other hand, if the volume remains unchanged, the inward pressure cannot possibly decrease; the surface tension of the capillary water takes the place of the external load. Like a rubber skin, it opposes any tendency to expansion.

Thus all phenomena associated with the cohesion of clays are capable of being explained by the single factor of surface tension. Cohesion is the internal frictional resistance produced by the capillary pressure. As the cause of the capillary pressure—the surface tension of the capillary water—is an external one, merely acting on the surface of the clay, the cohesion due to the capillary pressure may be called the *apparent cohesion*, in opposition to the *true cohesion* produced by initial friction*. As the initial friction was found to amount to not more than about 20 g./cm.², the true cohesion is very small compared with the apparent cohesion.

The shearing strength of a mass of clay is equal to the product of the capillary pressure and the coefficient of internal resistance. This relation, however, proves to be valid for the plastic state only, while in the semi-solid and solid states the shearing strength is smaller, just as the shearing strength of solid bodies is very much smaller than the product of the intrinsic pressure times the coefficient of internal resistance. The latter phenomenon seems to be due to important secondary stresses (unequal internal stress-distribution), and it is on the point of being thoroughly studied by various English investigators. (A. A. *Griffith*[1] Prof. B. P. *Haigh*[2] and others.)

Properties of Capillary Water—Since shrinkage is

NOTE—The term "initial friction" as used by the author denotes the shearing strength of clay when not under pressure, either external or capillary. Extended investigation of initial friction showed it to be far too small in amount to account for any of the properties commonly grouped under the general term "cohesion of clay." The internal friction which acts in the interior of a clay subjected to either load or capillary pressure is the sum of (1) initial friction, which is practically independent of the intensity of the pressure, and (2) the frictional resistance set up by the pressure, which is proportional to the intensity of the pressure. Even at small pressures, however, the first item is almost negligible compared to the second.

due to the surface tension of the capillary water, it ought to be possible to calculate the intensity of the transition pressure from the average width of the voids of the clay. As the specific gravity of water is unity, the maximum capillary pressure in grams per square centimeter is equal to the maximum capillary height h in centimeters. The data obtained by a wet mechanical analysis allowed the author to estimate for the yellow residual clay mentioned above a maximum capillary height of 306 m., or 30,600 cm. This value corresponds to the width the voids would have at the shrinkage limit. Hence the intensity of the transition pressure ought to be of the order 30,600 g. or 30.6 kg./cm.^{2}. But, as previously noted, determination of the transition pressure for this clay gave the value 171 kg./cm.^{2}. The cause of the obvious disagreement between the two figures mentioned resides in the fact that water enclosed in voids of width less than about 0.1 micron ($= 0.1\mu = 0.0001$ mm.) has properties different from those of water contained in wider vessels. The viscosity of the water as well as the rate of evaporation rapidly increases below this limit, as has been proved by permeability measurements.

A very important consequence hereof is that the capillary water of clays is but partially evaporable. If the capillary water contained in clays could completely evaporate, as does the capillary water of sands, clay upon drying would lose its cohesion. The cohesion of clay dried at normal temperatures is however almost twice as great as the cohesion at the shrinkage limit. As the cohesion of a reversible colloid is due wholly to the surface tension of the capillary water, it follows that part of the capillary water remains in the voids of air-dried clay forever without evaporating.

According to the definition of the shrinkage limit, the width of the voids of the clay remains constant below the shrinkage limit, although the moisture content continues to decrease. Evidently the surface of the capillary water retreats from the outer surface of the clay into the narrowest parts of the capillary system. This process decreases the total length of the contour line along which the surface tension acts; nevertheless the cohesion continues to increase. Hence we must conclude that the surface tension per unit of length of the contour line increases just as does the viscosity as the size of these very small capillary channels decreases. This conclusion confirms what has been assumed concerning the cause of the disagreement between the actual and the theoretical value of the capillary pressure.

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[1] "The Phenomena of Rupture and Flow in Solids," A. A. Griffith, *Phil. Trans.* Royal Society (London), 1920, pp. 163-198.
[2] "Theory of Rupture in Fatigue," B. P. Haigh, Proceedings of the International Congress of Applied Mechanics, Delft, April, 1924.
[3] "Die Viskosität des Wassers in engen Durchgangsquerschnitten," K. Terzaghi, *Zeitschrift für angewandte Mathematik und Mechanik*, 1924.

Grouting Reinforces Rock at Oak Grove Surge Chamber

Seepage through Concrete Lining Cut to 0.42 Sec.-Ft. by Grouting in Shaft and Chamber with Minimum Plant Shutdown—Novel Extensometers for Tests During Work in Tunnel

A FEATURE of the Oak Grove hydro-electric plant, recently completed by the Portland Electric Power Co. on the Clackamas River 57 miles from Portland, Ore., is a Johnson differential surge tank built into a knoll at the top of a penstock which leads down a steep slope to the power house. When water was first admitted to surge tank and tunnel in July, 1924, the concrete lining cracked, resulting in considerable seepage and necessitating the operation of the plant under reduced head while surge tank and tunnel were being repaired. Grouting was selected in preference to a steel lining as a method of repair and after two successive grout treatments, described in detail in the following, seepage was reduced to what was considered a negligible quantity. An article describing the 9-mile line leading to this surge chamber appeared in *Engineering News-Record*, Dec. 27, 1923, p. 1067.

The knoll in which the surge tank is built is termed geologically an erosion remnant. It stands out away from the main ridge from which it is separated by a saddle some 300 ft. lower than the top of the knoll itself. On all sides the slopes of the knoll are steep, for the most part being about 35 deg. with the horizontal. The water tunnel enters the knoll horizontally at the east side and after passing under the surge chamber drops to a level some 38 ft. lower before reaching the outlet portal. The surge chamber was located so as to take advantage of the support which the hill would afford in carrying a concrete-lined shaft some 200 ft. above tunnel level.

At El. 1817 on the west face of the knoll there is a contact between columnar basalt above and volcanic tuff below. This tuff is a volcanic ash compacted by pressure until it resembles shale and is practically impervious so that the natural drainage from the hill comes out along this contact. The columnar basalt generally changes to a more broken material toward the top of the knoll where the rock is more or less shattered.

At the east end of the tunnel through the knoll steel lining was used for a distance of 170 ft. and for 100 ft. at the west end, leaving a 167-ft. central section in which the lining consisted only of unreinforced concrete. Because of the depth of cover it was believed that this central section would easily withstand a water pressure of 80 to 90 lb. per sq.in. In the surge chamber proper some reinforcing steel was used, beginning at 8 ft. above the bottom (El. 1968) and continuing to the top of the tank. Below El. 1988 the reinforcing was light but above this level the tank was reinforced against full hydrostatic head. No reinforcing whatever was used in the lining of the 14-ft. shaft connecting surge chamber and tunnel.

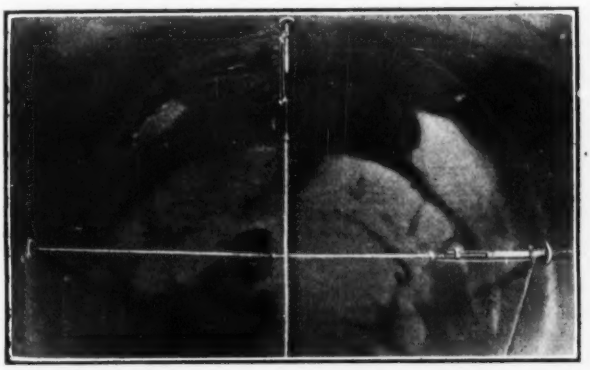
Owing to the nature of the rock in the surge chamber and in the upper half of the shaft, light timbering was used during construction more to protect the miners than to prevent cave-in. This timbering was suspended from a collar on top of the ground and was framed in segmental rings, back of which vertical lagging was used. The rings were hung by hook bolts and thus as the concrete was poured the successive segmental rings and lagging were removed, making it possible to pour concrete directly against the rock.

After allowing the last concrete poured a period of three months in which to harden the first water was

admitted July 17, 1924. Tunnel and shaft were filled slowly and when water reached El. 1910 a sharp increase in seepage of water was noted in the drain at the east portal of the tunnel. When El. 1975 (which is about 15 ft. above the bottom of the surge chamber proper) was reached water began coming out at the contact along the west face and later, at El. 1880, also at the same level on the north side of the knoll. The total seepage out of the knoll at this time was estimated as 5 sec.-ft.

The tunnel and surge chamber were unwatered and an examination made. In the shaft two vertical cracks were found directly opposite, extending from the bottleneck at the top of the shaft down to the tunnel and for a distance of about 25 ft. in both directions from the shaft along the roof of the tunnel. As the cracks in the tunnel itself did not seem to be serious and since the power was badly needed on account of the low stage of water at other hydro-electric plants, it was decided to operate the plant on a reduced head such as would be possible without putting the tunnel under pressure. This was done by the use of a wooden spillbox constructed at the east portal and arranged to prevent any pressure head from coming on the tunnel.

A study of conditions in surge chamber and shaft then led to the conclusion that there were three possible

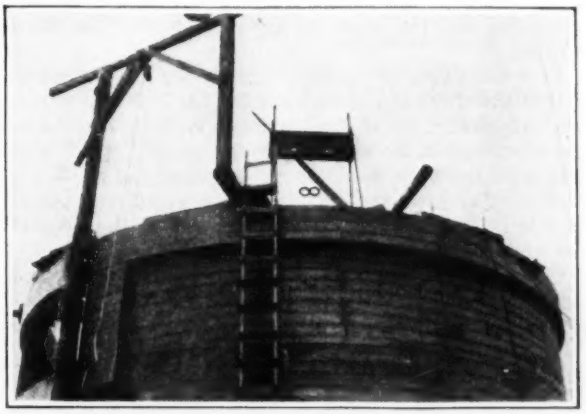


EXTENSOMETERS MOUNTED IN TUNNEL

causes of cracks in the lining: (1) The natural shrinkage of concrete after pouring and the further contraction due to introducing cold mountain water; (2) a shattering of the rock by blasting and a tendency of this shattered material to sag inward during the time interval between excavation and lining with concrete and (3) natural interstices in the columnar structure of the rock of which the hill is composed. The first two, it was believed, would have caused only very small cracks, but the third, it was thought, might well have been responsible for the excessive seepage.

If the remedy were to be effected by putting a steel lining in the entire unreinforced concrete portions of the tunnel, shaft and surge, it was believed that there would be difficulty in connecting the several sections of steel lining without materially decreasing the diameter of the section, and it was also believed that such a steel lining would have required grout between it and the concrete lining unless the steel used were to be heavy enough to withstand the pressure unsupported. Finally with this method of repair it would have been necessary to suspend operation of the plant entirely for a period of three or four months.

On the other hand, if the repair could be effected by grouting behind the concrete lining the plant could continue operation during repairs and the ultimate section would be that contemplated in the original design.



EXTENSOMETER DIALS ON TOP OF SURGE TANKS

Repair by grouting involved some uncertainty and in deciding on this method company officials had to balance their judgment against the risk that this plan could not be satisfactorily carried out.

A platform or safety stage was hung in the shaft just above the tunnel and another working stage was suspended above this from four hand crabs which made adjustment for elevation simple and quick. Holes were then drilled through the lining to a total depth of 4 ft., using a hand power drill and 2-in. steel. This size of hole permitted using 1½-in. pipe for casings. These casings were at first grouted in but later it was found that lead wool calked in around the casings served the purpose better.

A grouting plant was assembled on top of the knoll and two grout guns were mounted on the working stage in order to be near the work. They were supplied by material delivered down the shaft by means of a hoist. After experimenting with the arrangement it was found unnecessary to have the guns close to the work, and grout was ultimately delivered through piping for a distance of 250 ft. This proved to be a much more convenient method of carrying on the work. Plugging in the lower end of the grout line did occasionally occur but was not a serious drawback to the scheme of keeping the grout guns outside.

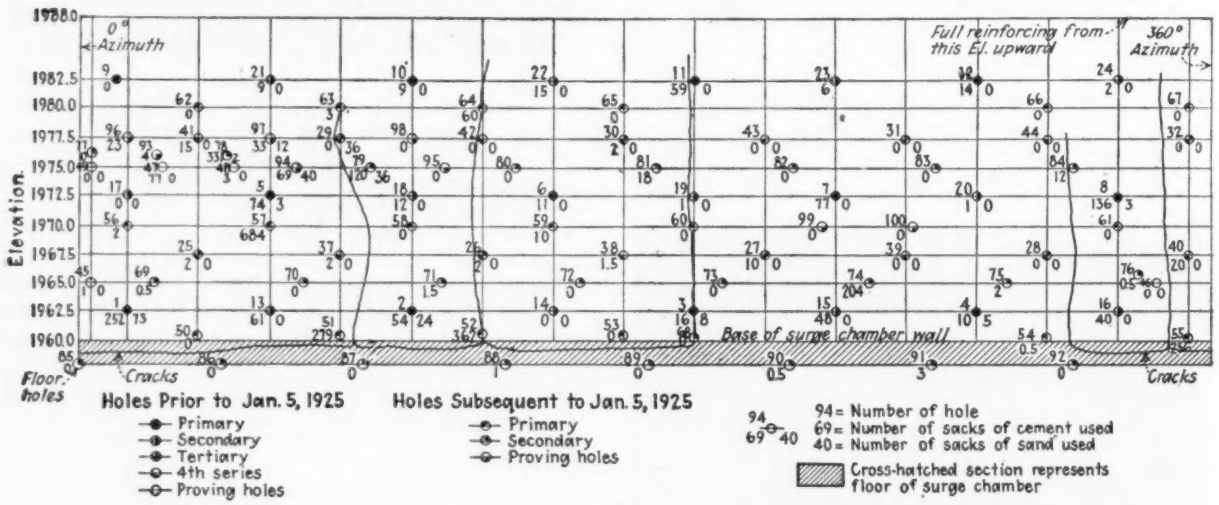
The grouting of all holes was begun with a mix of one part of cement to 15 parts of water and this proportion was continued for 20 charges of the guns. If the hole then continued to take the thin mix without any decrease in length of time of discharge a thicker mix was used until the proportion had gradually been thickened to 1 part of cement to 3 parts of water. This was the thickest mix that could be handled well in the guns and seemed to do the most good. This mixture was then continued until the hole was plugged.

In holes where pockets or voids were known to exist, sand was used in the proportion of one part of sand and one part of cement to six parts of water. The air pressure varied from 135 to 90 lb. per sq.in., depending on the location in elevation of the holes being grouted. It was found necessary to screen the cement to prevent lumps from prematurely plugging the holes.

The grouting was done in two operations; the first including the grouting of the shaft and the lower 28 ft. of the surge tank, while the second gave attention primarily to the tunnel and the lower part of the surge tank. Between these two operations the surge chamber was filled and the effect of grouting up to that point was noted.

Very little cement could be forced into the lower portion of the shaft but upon reaching El. 1910 an annular void was found which seemed to have been formed by the compression of the shaft walls; grout forced in at this level not only went entirely around the shaft but passed on upward and finally enough grout was put in at this level to bring it through cracks in the floor of the surge chamber.

In a report made by the resident engineer he says with reference to the first grouting period, "The rock around the bottom 30 ft. of the surge tank seemed to be so loose that sand was used with the grout. A considerable amount of this material was forced in but apparently it was too coarse and did not penetrate far enough into the interstices to make the surrounding mass sufficiently stable."



GROUTING CHART FOR LOWER PORTION OF SURGE CHAMBER

This grouting of the surge chamber before subjecting it to pressure was an attempt to forestall cracking there after cracks in the shaft below (and before any considerable pressure had been put on the surge chamber) had thrown suspicion on the unreinforced or only partly reinforced sections. After completing the grouting a ½-in. coat of gunite was put on the walls of shaft and surge. This was to seal the existing cracks as well as to make watertight any porous places there might have been in the concrete.

After this first grouting operation which continued from September to Dec. 5 in 1924, a water test was made on Jan. 5, 1925. The tunnels were filled up slowly, three days' time being consumed in the filling, and the seepage was measured at four points throughout the test. When the shaft had been filled to El. 1960 water began coming out through the contact, and from this height up to El. 2035 a steady increase in the seepage was noted. When the water level was brought up to the full height for which the plant was designed the turbine was put in operation and kept in service for 22 hours during which time seepage measurements were continued. At the end of this period there was a flow of 735 gal. per minute from the four main points and in addition springs had appeared through the basalt higher up where measurement was impossible. Altogether it was estimated that about 2 to 3 sec.-ft. of water was escaping from the cracks in tunnel and surge.

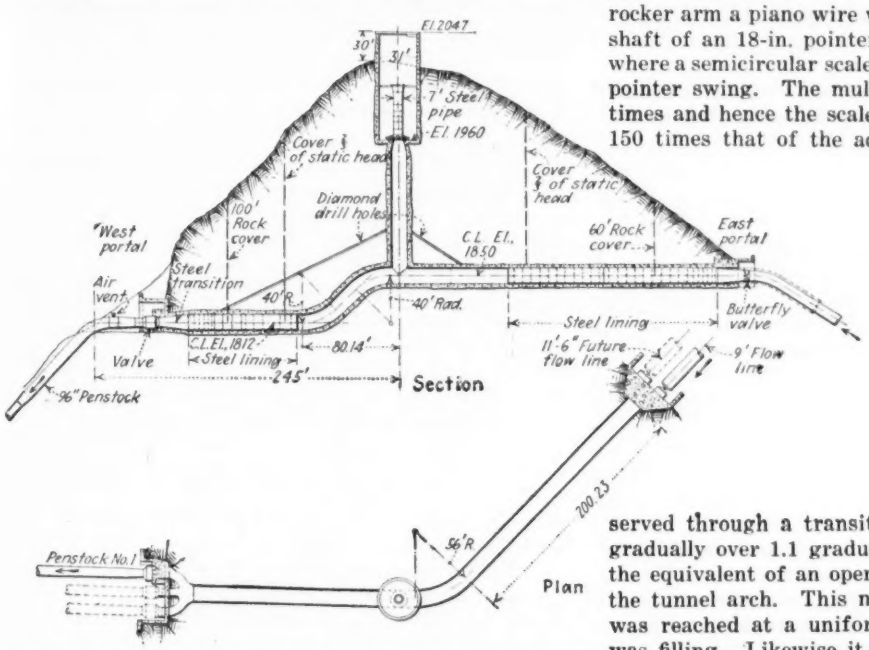
The tunnel was then unwatered and another examination made. In the tunnel it was found that the crack in the arch that was 25 ft. long before had increased its length to 80 ft. and now extended to the steel lining However, the length of the other crack in the tunnel arch, extending west from the shaft, had not increased. On both sides of the invert cracks had appeared for almost the entire length of the concrete-lined portion of the tunnel. These two cracks were along field joints between the pouring of invert and arch walls.

In the shaft the upper section was intact but in the lower 30 to 40 ft. the same two cracks that were found after the July water test were in evidence. No new cracks had appeared.

In the surge chamber four cracks had developed in the walls and one in the floor. The latter was in general along the arc of a circle, indicating that the walls had moved outward slightly, increasing the diameter of the surge chamber to this extent.

More intensive grouting was then decided upon, and as it was now convenient to take the plant out of service over each week end, the plant was shut down from Saturday morning until Monday morning and during this time work was carried on in the tunnel. During the remainder of the week work was advanced in shaft and surge chamber with the tunnel in service as a flow line.

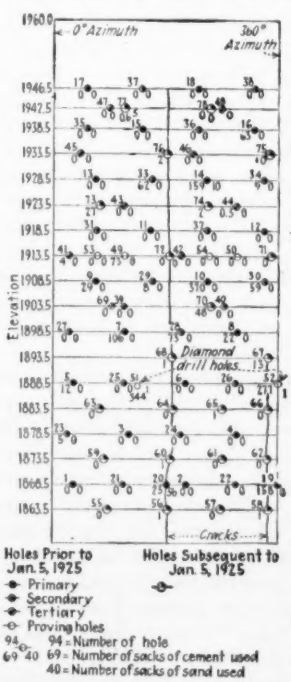
In sections where grouting had been done previously it was now necessary to drill deeper than at first to reach shattered rock. All holes drilled in this grouting period were therefore made 8 ft. deep. In the bottom of the surge chamber, where grouting had been done before the Jan. 5 test to strengthen the rock walls, it was now concluded that that grout had not gone far enough into the rock to provide the desired support. In this portion of the surge chamber particularly, large amounts of grout were forced through the 8-ft. holes.



PLAN AND ELEVATION, TUNNEL AND SURGE CHAMBER

In the tunnel 115 holes were drilled, in the shaft 24 more holes were put in and in the surge tank, 18 holes, all 8 ft. in depth. By drilling all of the holes before grouting began the progress of the grout could be watched. It sometimes traveled four holes or a distance of 40 ft. from the point of entry. As grout appeared at open holes these were successively capped. After all holes had been given all the grout they would take, a month's time was allowed to elapse before the final water test was made.

In order to show just what happened in the tunnel itself during this final test a device was built up for indicating on large dials on top of the surge chamber the amount of separation or opening of the tunnel cracks under pressure. This consisted of a pair of extensometers set in the tunnel near the base of the surge shaft, one vertical and one horizontal. Each extensometer consisted of a pair of 1¼-in. pipes with a floor flange bolted firmly into either wall and a telescope or slip joint section that allowed one pipe to slide freely inside the other in response to any inward or outward movement of the tunnel walls. A rod across this slip joint from a sleeve on one side to a rocker arm and pivot on the other multiplied the actual movement in the sliding section about 15 times. From the end of this rocker arm a piano wire was led over sheaves and to the shaft of an 18-in. pointer on top of the surge chamber where a semicircular scale was fixed on which to read the pointer swing. The multiplication here was about ten times and hence the scale readings showed a movement 150 times that of the actual movement in the tunnel.



SHAFT GROUTING CHART

On May 5, 1925, the final test was made, the tank being filled this time in about 8 hours. After a 27-hr. period during which time the water had stood at the full head, the leakage at the four measuring points showed only 194 gal. per min. (0.42 sec.-ft.) and this amount remained stationary. The pointer recording movement in the horizontal extensometer in the tunnel (as observed through a transit telescope) was seen to move gradually over 1.1 graduations on the scale, which was the equivalent of an opening of 0.07 in. in the crack in the tunnel arch. This maximum opening of the crack was reached at a uniform rate as the surge chamber was filling. Likewise it decreased uniformly when the surge chamber was being emptied. The arrow recording movement of the vertical extensometer did not show any separation of arch and invert; on the contrary, when the horizontal extensometer recorded the opening of the crack in the arch there was a slight but noticeable tendency for the roof to lower. When water pressure was later removed the pointer recording this movement showed a very slight movement in a negative direction, indicating a tendency to closure of the crack as the pressure went off.

After a thorough test at full elevation the water was drawn down to El. 1960 for one more examination of surge and shaft interiors. Six extensometer devices had been placed across cracks at various points in the tunnel and shaft (in addition to those recording on the dials) and these showed a maximum opening of ⅛ in. The surge chamber itself was found to be intact and at only two places near the bottom of the shaft and in the tunnel arch was there any back-pressure seepage. When the plant was put in service observation over a three-weeks' period showed no further increase in the leakage.

In the final test the indicating device showed a slight opening in the tunnel crack six hours before any water appeared through the contact at the face of the hill. This was about twice the time-lag believed to have occurred in the previous test and is believed to show that there is no damaging amount of pressure built up within the knoll and that the water escaping is only in the form of seepage. The seepage is clear water.

Because of the expansion and contraction of unreinforced concrete, company officials are of the opinion that it would be a practical impossibility to carry on grouting operations to the point where a surge chamber in basalt such as surrounds this concrete lining would be absolutely watertight, but that with seepage reduced to the low amount now recorded it is regarded as negligible.

H. A. Rands, the company's project engineer on the Oak Grove development, worked out the details of the grouting methods, and V. L. Johnson, resident engineer, was in charge of the work.

Concrete Arch Bridge of Unusual Form and Details

Through-Arch Crossing Being Built at Piqua Over Miami River—Reinforced-Concrete Hangers Have Hinge Joints

By W. H. Rabe
Chief Designing Engineer of Bridges, Department of Highways and Public Works, Columbus, Ohio

A CONCRETE bridge of through-arch type is being built over the Great Miami River at the east edge of the city of Piqua, on the road to Urbana. The type is becoming a familiar one on the Ohio state highways, but as it is not often used elsewhere and as its form and certain of its details are particularly interesting it is described here. The use of vertical hinge joints in the reinforced-concrete hangers is perhaps most noteworthy of the details.

The structure, on a 10-deg. right-hand skew location, is 470 ft. long. It comprises five 80-ft. spans carrying a 24-ft. roadway and two 5-ft. sidewalks. The height from the pavement to the bottom of the stream is 30 ft. and the depth from the bottom of the stream to the bottom of the pier footings, 10 ft.

Several reasons combined to determine the type selected: The location of the bridge—at the edge of a municipality—suggested the use of an attractive concrete structure; the waterway requirements specified by the Miami Conservancy District could be taken care of much better by the through-arch type than the spandrel-filled type; and the Department of Highways has

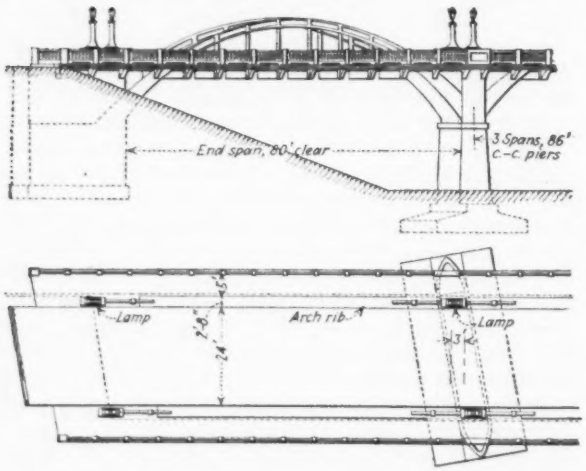


FIG. 1—THROUGH-ARCH OF CONCRETE BRIDGE OVER MIAMI RIVER AT PIQUA

found the through-arch type to be economical and popular with the public.

To assure safety against scour the piers and abutments have pile foundations, with a maximum calculated load of 15 tons per pile. The piers are solid below the springing line and hollow above. The design calls for pier noses of the type used by the Miami Conservancy District. The abutments were made of hollow cellular type in order to reduce the load on the footings; they are equipped for future interior inspection.

Structural Features—The floor system of the arch spans consists of a roadway slab supported by and integral with concrete floorbeams spaced 7 ft. 5 in. centers; and a sidewalk slab supported by and integral with concrete brackets cantilevered from the ends of the floorbeams. Expansion and contraction of the slab is taken care of by a shelf expansion joint in the second beam and bracket from either end of each span and by similar joints at the edges of piers and abutments. Lateral movement at these latter joints is resisted by

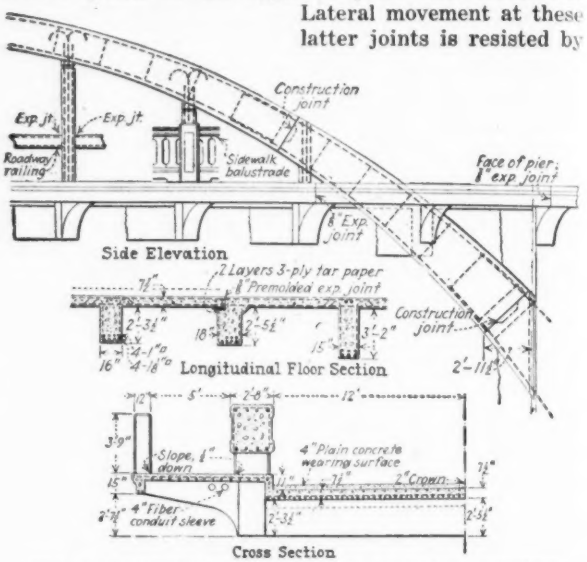


FIG. 2—CONSTRUCTION DETAILS OF PIQUA BRIDGE

cast-iron anchorages in pairs, one sliding longitudinally upon another. At the other shelf joints the lateral movement is resisted by smooth bars sliding longitudinally in pipes. The first floorbeam and bracket is supported by being cast integrally with the arch rib; the others are supported by hangers.

Each hanger consists of reinforcing bars bonded in the arch rib and the floorbeam. With the exception of the hanger supporting the fixed beam at the expansion joints, there are five main bars in each hanger; they are placed in a single vertical plane, to permit the hangers to hinge at top and bottom. To assist this hinging action the concrete at the bottom of the hanger and at a point near the top is separated from the adjacent concrete, except for small contact surfaces around the hanger bars. Each of the main bars is encased in a copper tube at this point, to keep moisture from the steel. These hinge joints have been provided on this design to prevent flexure cracks in the hanger concrete.

The arch ribs are 2 ft. 8 in. wide, 2 ft. 2 in. thick at the crown and 3 ft. 10 in. thick at the skewbacks. The curve of the arch axis lies midway between a parabola and the segment of a circle. Its rise is one-fourth the span, and the intrados at the crown is 9 ft. above the sidewalk surface.

Along the outer edges of the sidewalks is a concrete spindle railing with large posts over each pair of pier brackets and small posts over the other brackets. Between roadway and sidewalk there is a single rail between hangers with large posts over the piers and abutments. Each of these large posts supports a concrete lantern standard with a lantern of the Euclid type.

Paving—Plain concrete 4 in. thick forms the pavement. The west approach, leading into Piqua, is paved with reinforced concrete; the east approach is surfaced with gravel temporarily until a new underpass is constructed under the B. & O. railroad tracks.

Concrete Mixtures—For the railing, lantern standards and pavement, 1:2:3 concrete was used, for the arch

ribs above the floor system and for the hangers 1:1½:3, and for the remainder of the structure 1:2:4.

Loads and Stresses—The roadway floor system was designed for a live-load of two trucks passing, each with a gross load of 15 tons with 12 tons load on the rear axle; axles 14 ft. apart; wheels on one axle 6 ft. center to center; near wheels of passing trucks 3 ft. center to center; with the trucks placed to cause greatest stress. The sidewalk floor was designed to carry 80 lb. per sq.ft. The hangers are proportioned for these two loadings in combination. For the arch ribs the sidewalk load was taken as 70 lb. per sq.ft. and the roadway load as described above with two lanes of traffic and with 14 ft. between axles of succeeding trucks; loaded lengths giving greatest stress were used.

For impact a variable fraction averaging ½ of the live load was assumed for the floor system and hangers and averaging ⅛ of the live load for the arch ribs. A temperature range (intended to cover also rib shortening) of 30 deg. above and 55 deg. below the temperature at time of setting of concrete was assumed.

Unit stresses as follows were used: tension in steel, 16,000 lb. per sq.in. (for the steel in the arch ribs the maximum calculated unit stress is less than 10,000 lb. per sq.in.); compression in concrete due to bending, 750 lb. per sq.in., except in the arch ribs, in which the maximum (including temperature and rib shortening) is 800 for the 1:2:4 portion and 930 for the 1:1½:3 portion. Shear in concrete, 40 lb. per sq.in. for that portion not reinforced for shear and 120 lb. for all members reinforced for shear.

This bridge was designed by the writer. The contract was awarded on June 23, 1925, to Stout & Stout of Stoutsville, Ohio, who have had considerable experience in concrete through-arch construction. The contract price is $133,499.30, and the date set for completion is July 1, 1926. The work is under the supervision of the Department of Highways and Public Works, of which L. A. Boulay was director at the time the contract was let and G. F. Schlesinger is the present director, H. J. Kirk is state highway engineer, and J. R. Burkey is chief engineer of bridges. Richard Orth is the engineer in charge of construction.

It may be of interest to note that tests will be conducted on this structure by the committee on concrete and reinforced concrete arches of the American Society of Civil Engineers (Prof. Clyde T. Morris, Columbus, chairman). Readings will be taken at various stages of construction to determine the horizontal, vertical and rotational movement of the piers as they are subjected to the various load conditions. The Department of Highways is co-operating in this work by arranging for the installation of equipment and the taking of the field readings. The testing equipment will be installed and readings taken under direction of Professor Morris.

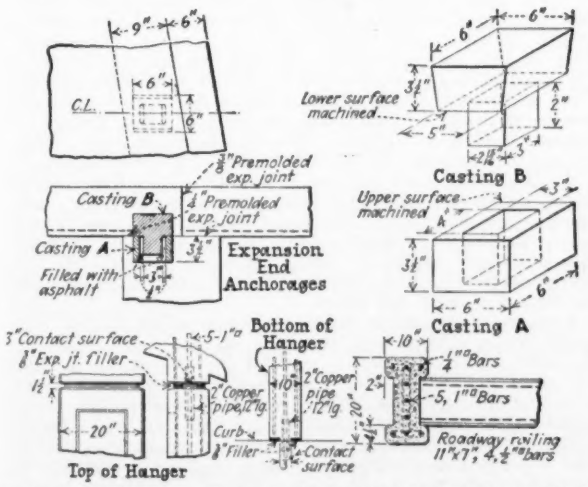


FIG. 3—HANGER HINGE AND END ANCHORAGE OF FLOOR

The Railway System of China

WITH a total of 7,456 miles of railway in China at the end of 1923, 4,614 miles of main and branch lines were owned and operated by the government, according to the ninth annual report to the Minister of Communications by the Department of Railways, of which C. S. Liu is director.

This total for the government lines includes 240 miles open to construction trains but not to traffic and also 303 miles of the Peking-Mukden line which during 1923 were temporarily under control of the province of Fengtien, although owned by the central government. The railway system included seventeen different lines in nineteen provinces, with an aggregate of 5,850 miles of track, including sidings and 16 miles of double track. In cost of construction and equipment the lines range from $88,353 to $226,676 per mile, with an average of $148,622. Of the total operating revenue of $119,405,638, the operating expenses consumed $64,724,460 or 54.2 per cent. Of this total revenue also, the passenger service provided 32.34 per cent and the freight service 59.04 per cent. Maintenance-of-way averaged $2,757 per mile, of which about 50 per cent was for ties. Traffic for the year 1923 comprised 40,444,657 passengers and 29,596,408 tons of freight, with an average haul of 52.1 miles per passenger and 107.2 miles per ton. Employees averaged 25.8 per mile of line.

Next in importance to the government lines are the "concession" railways, built and operated by foreign companies. These include the Chinese Eastern Ry., 5 ft. gage; the South Manchuria Ry. and the British section of the Kowloon-Canton Ry., of standard gage; and the Yunnan Ry., of meter gage; they total 2,080 miles of main and branch line, exclusive of sidings. In addition to these, there are about 36 private lines ranging in length from two to 190 miles and aggregating 762 miles, including 24- and 30-in. gage, meter gage and standard gage. Some of these lines have been financed by private capital, others by local authorities. Some were built as public carriers; others for serving mines or other industries, but also handling some public business. The railway equipment is listed below:

Railways	Locomotives	Pass. Cars	Freight Cars
Government	1,121	1,698	16,768
Concession	952	1,339	16,602
Private	126	211	2,026
Total	2,199	3,239	35,396

With a total population of 438,771,367 and an area of 1,909,240 square miles, China in 1923 had 17 miles of railway per million population and 4 miles of railway per 1,000 square miles. These are compared in the report with 124 and 47 miles respectively for Japan; 146 and 32¼ miles for India, and 2,294 and 72 miles for the United States. It is noted in the report that owing to the extent of waterways in China the proportion of railways to population and area will always be low.

Snow Drift Prevention and Control on Highways

Based on a State-Wide Snowfall Survey — Prevention and Control of Drifts Advocated as Best and Most Economical Way of Keeping Roads Clear

By V. R. Burton
Engineer on Special Assignments, State Highway Department, Lansing, Mich.

FROM 85 to 90 per cent of our total annual snowfall in all sections of Michigan is from storms of not more than 6 in. intensity. The average storm is between 2 and 3 in. in intensity. If this snowfall were undisturbed by the wind, removal would be a simple problem, as only the lightest kind of equipment would be necessary in this work and the cost would amount to but a fraction of the actual figures. The nearer this condition is approached, the better and cheaper will be winter highway service.

Theory of Drift Formation—Snow drifts are caused by the deposit of wind-borne snow, a little of which is carried by the wind as it falls and very much greater amounts of which are picked up and driven along the surface. When the velocity of the wind is not enough to carry the snow particles in suspension, they are dropped to form the drift in much the same way that sand bars in rivers and sand dunes in the desert are formed.

The drawings show the probable methods of drift formation in two situations. The first shows a tight barrier formed of a fence on which the boards are laid up without any spaces between. The second shows a fence on which the alternate boards are omitted and a part of the wind allowed to pass through it. In both cases the wind is coming from the left and is indicated by arrows in the direction of movement.

Let us first consider the manner in which the snow is carried along the ground. As the wind sweeps over the surface of the snow the friction of the moving air on this surface causes the lower thin layer immediately in contact to lose considerable of its velocity, the next above it loses a little less and so on. The relatively slower speed of the lower layers transform what was originally linear motion into rotational motion, and forms an eddy which has its axis parallel to the snow surface and is in a direction at right angles to the course of the wind. In the sketches shown, these surface eddies extend only a short distance above the surface, due to the fact that the capacity of air to transfer an effect of this kind is very limited, due to its lack of internal friction. These small eddies, however, are of sufficient force to raise a certain amount of snow on the side of the eddy on which upward motion is taking place, high enough so that the faster moving layer above may reach some of it and move it some distance ahead. This process continues and whole fields may be swept bare of snow because of it. It should be noted that nearly all of the snow moved in drifting is carried by this process and not from falling snow driven by the wind.

Effect of Tight Fence—As the wind strikes the tight barrier, in the first drawing, part of it is deflected upward and part downward. That part which is deflected downward strikes the earth and is again deflected this time to the left in a direction opposed to the wind which is sweeping up to the barrier. The opposing action of these two air currents, next to the ground, forces them to rise upward. This upward air current is again bent in by the oncoming wind and a part of it forced to complete the circuit again. The eddy thus formed is very much greater in size and force than the small snow carriers, as it is due to an actual deflection of the wind current. The combination of the two upward forces is sufficient to permit the major part of the air current rising from the ground to join the upper air current which is continually deflected upward. As this upward current reaches the top of the barrier the wind coming directly from the left meets it and deflects it downward beyond the barrier. The friction of the wind on the top of the barrier causes some slight eddy effect but not great in amount.

Directly behind and below the top of the barrier the air is still and in the case of a high wind and tight fence a partial vacuum may be created. In any event the lower layers of the wind current coming over the top are slowed up very materially by the resistance of this quiet air and also because this current must spread out to again reach the actual surface of the settled snow.

Snow is deposited in a small amount in the dead space beneath the junction of the two opposing air currents in front of the barrier. Very much larger amounts are carried completely over the barrier and are deposited behind it. The lower layers of the air current carry the most snow and as soon as this current has slowed down beyond its capacity to carry the load of snow, this snow is dropped in the quiet space behind. The largest amount will pile up at a certain point behind this barrier whose distance from the barrier depends on the velocity of the wind, the tightness of the barrier, the barrier height and the specific gravity and texture of the snow.

Effect of Slat Fence—The action in the case of the slat board fence with every alternate board of the tight fence removed is much the same, but the eddies are somewhat more complicated. The wind strikes the separate boards in the manner shown in the sketch, a part being deflected upward and a part downward. The upward and downward currents from adjacent boards are now opposed in direction and a part of the air current turns toward the opening and a part back toward the oncoming wind. The lower eddy of this series is forced upwards by the resistance of the ground and this coupled with the resistance of the fence and eddies at the openings forces the air up and over the barrier in the same way as before. Not nearly so strong an eddy is created in this case, however, and a large amount of the snow is driven through the lower openings.

As the air streams through the openings the fence board edges again produce individual air currents which are opposed in direction. The resistance of the quieter air behind the barrier breaks up the air current going through into a chaotic series of small eddies in which sufficient energy is lost to cause the deposition of the snow brought through and over the fence.

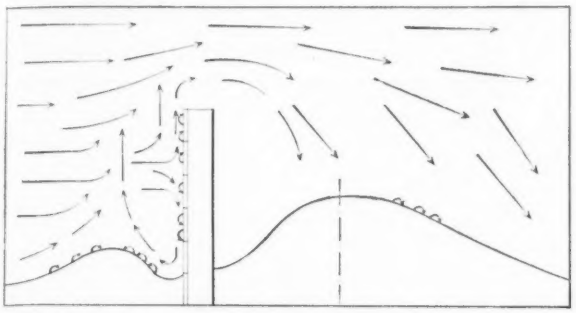
A picket fence gives much the same effect as the slat board fence, except that the axes of the small eddies in the rear of the fence are vertical instead of horizontal. The direction of the eddy axes seems to have little to do with the effectiveness of the fence as the picket fence forms drifts even more readily than the slat board fence.

The action of natural wind breaks is much the same as that described above but the action of the air currents is naturally very much more complicated. Anything which tends to slow down the normal wind velocity will cause a

Probably the most complete study ever made of snowfall as it affects the task of keeping public roads open for winter traffic has just been completed, in its major parts, for the State Highway Department of Michigan. A section of the full report, not yet published, is printed here. It discusses drift formation, prevention and control. In a later article there will be given an outline of the essential findings and conclusions of the survey. It is on these that the reasoning for drift prevention is based. With winter approaching it seemed preferable to present the cure before giving the analysis of the character of the malady. That Mr. Burton has arrived at his remedy logically we believe the reader can take on faith.—Editor.

drift to form. Tree branches close to the ground, hedges, brush, weeds, etc., all are frequent sources of trouble from snow drifts.

It is evident that the distance behind the fence over which the drift forms is directly related to the height of the fence. Unfortunately little is known about this factor and a determination of its value, taking into account wind velocity and the specific gravity of the new fallen snow, would be of great assistance in snow removal work. A



DRIFT FORMATION AT TIGHT BOARD FENCE

rough approximation sometimes given is 8 or 10 ft. distance for each foot of height of fence.

Drift Danger Points—The topography combined with the culture of the country through which the road runs, influences the amount of drifting in it to a great extent. Rolling wooded country, where the road grade follows the surface of the ground very closely, gives the least trouble. Large flat fields of cultivated land, especially where fall plowing is practiced, are often swept bare and their snow stopped by a fence or weeds, falls in the highway. Even such small obstructions as the weeds and corn stubble remaining in the field after the crop is removed are sufficient to very materially reduce the amount of drifting adjacent to such fields where the snowfall is not too great to completely cover them.

Long shallow cuts are difficult to keep clear but the larger cuts except on side hill location do not give so much trouble. The snow storage capacity of the side slopes is so great as to take a large amount of snow before the roadway is blocked. In addition to this there is more opportunity for the snow to pass completely over the roadway before it drops. Side hill locations are especially bad where the high side is on the side of the direction of the prevailing wind. Gravity as well as the wind helps to bring the snow down the slope to the roadway.

Fills give very much less trouble and in many cases are swept bare by the action of the wind. On those fills high enough to require the use of guard rail, the old fashioned type of wooden rail with its board fence effect is a serious cause of drifting where ordinarily the road would have little snow on it.

Drift Preventives—In order to eliminate the trouble from snow drifts, it is evident that two courses are open to the highway authorities. Either the cause for the drift formation should be removed or if this means is impossible the drift should be caused to form far enough away from the road so that little snow reaches it.

In the first case all brush and weeds should be cut where they cause drifts to form within the roadway. The lower branches of trees should be trimmed. Some inducement should be offered property owners to replace hedges and old picket or wooden fence with wire fence. Wooden guard rail should be replaced with cable guard rail as soon as possible, but if this cannot be done immediately, all but the top rail should be removed in the fall. The plank forming the lower rails may be marked and stored for re-erection the following spring.

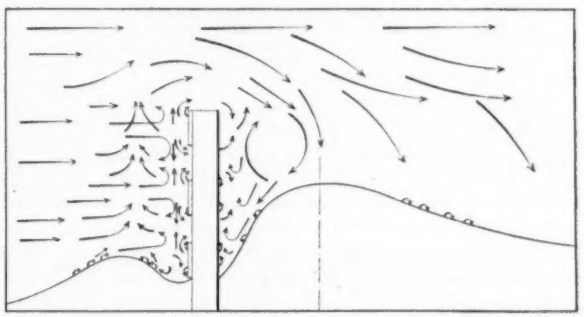
Care in the design of the highway grade should be exercised to avoid shallow cuts. The surface of the ground should be followed as closely as possible as it gives a road more economical in construction as well as one freer of snow drifts. At places where drifts are apt to form, it may be policy to raise the grade. This is especially true in flat open country where if the grade is raised somewhat the wind will actually keep the road clear of snow.

The faculty of the various types of wind break to form drifts may be made a help to us in our work instead of a serious sort of trouble, if they are only far enough back from the roadway so that the snow will drop before the roadway is reached. These wind breaks may be artificial such as the different types of snow fence, or they may be natural, formed by the various trees and shrubs along the highway, which were permitted to grow undisturbed from natural planting, or from those set out by man for that purpose.

Snow Fence Costs—Snow fences may be of three different types, permanent, removable and temporary. The permanent snow fence is usually made by the erection of a board or picket fence which is left in place the year round and maintained as an ordinary fence.

The ordinary removable snow fence consists of either a sectional board fence which is collapsible or a picket fence. The sectional board fence is made up of five or six 1x6-in. x 6-ft. boards nailed to a 2x4-in. frame to which are bolted collapsible braces of 2x4-in. timbers. This fence is usually made so that it forms a wind break from 5 to 8 ft. high. It is set up in the fall in these 16-ft. sections, leaving about a 2-ft. space between sections. In our heaviest snow sections the drifts formed by this fence may become so high that it is no longer operative. The fence is then dug out and re-set on top of the drift already formed. This is sometimes an expensive process as the fence has been frozen in and it is difficult to get it out of the old drift to re-set. Some of the sections may be badly damaged in getting them out of the ice. This type of fence costs about 30 to 35c. a foot to make and 10c. a foot to erect and then take down. From 5 to 10c. a foot is a fair figure for the cost of raising the fence after once buried.

The picket snow fence is simply the old fashioned wire woven picket fence and is manufactured by a number of different companies for this purpose. It may be obtained in 4- and 6-ft. heights. The 4-ft. fence comes in 100-ft. rolls weighing 350 lb. and costs about 10c. per foot delivered in Lower Michigan. The 6-ft. fence in 100-ft. rolls weighs about 540 lb. and costs about 20c. per foot delivered. This fence has the disadvantages that posts must be set in the ground for its erection. It is very convenient for transportation, is easily rolled up and weighs very much less per foot of fence than the sectional board fence. In situations where the fence must be dug out and raised during the winter, this type would probably not be satisfac-



DRIFT FORMATION AT SLAT BOARD FENCE

tory, as its construction is too light for the rough usage a fence receives in this practice.

The temporary snow fence is used in several sections of the state. This fence is made up of block of snow about 18x18 or 24 in., cut by a shovel and laid up like a stone wall, by hand. The first drift is formed by a plow furrow after the first snow has fallen and then blocks cut out of the drift formed later by this ridge. The cost of this type of fence is about 5c. per lineal foot of 5-ft. fence. This fence is very effective in the colder sections where there is no danger of losing it in midwinter thaws. It is easily raised to a greater height if it becomes necessary and it is not necessary to remove it in the spring. Much more attention should be given to the use of this type of snow fence in those parts of the state where its use is feasible.

The natural wind break offers far more possibilities for development on a large majority of the roads in our state than do any of the types of snow fence just mentioned. Shrubs and low bushy trees form an admirable wind break and if they are far enough from the roadway, act as satis-

factory snow fences. In many cases all that will be necessary to secure this type of drift prevention will be the encouragement of the natural growth. In other places it may be necessary to plant a hedge of some type to secure the desired results.

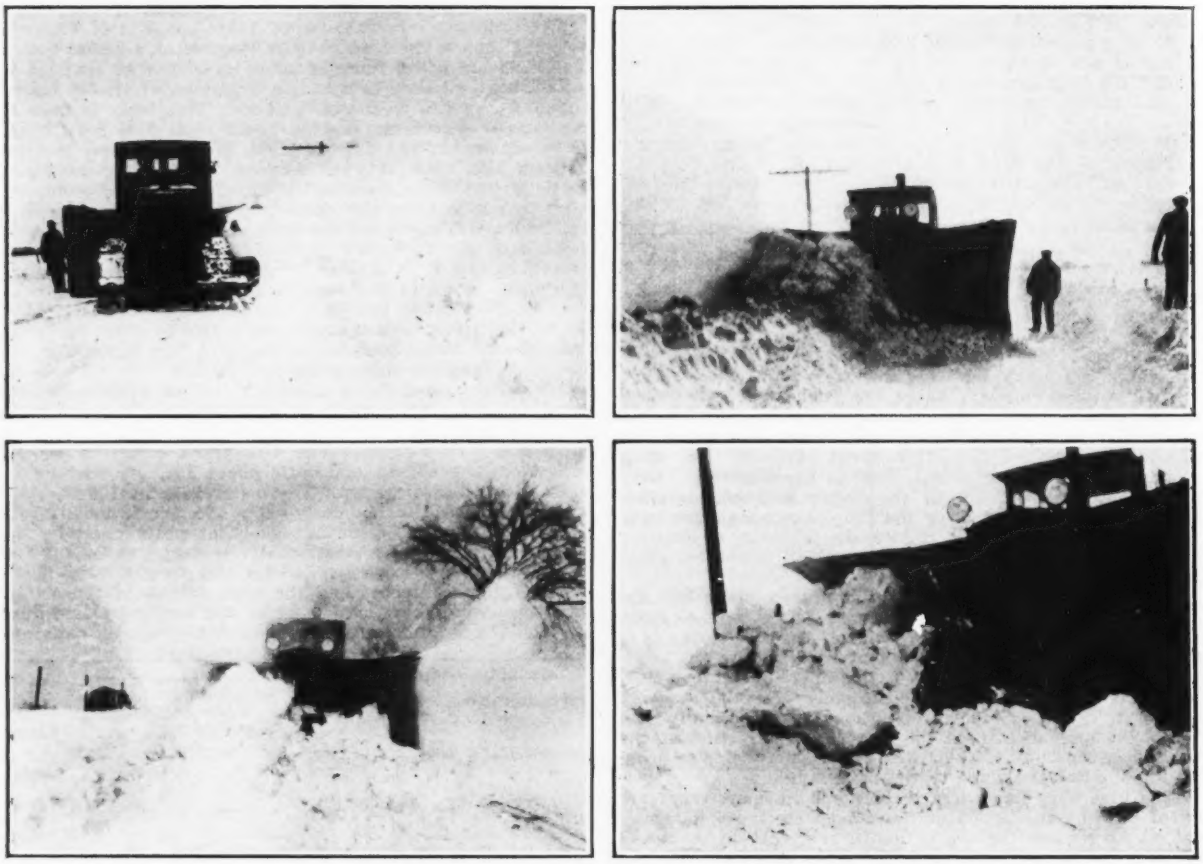
Right of Way Width—The use of any kind of snow fence presupposes its placing far enough from the road to drop the snow off of the roadway. Usually in the southern part of the Lower Peninsula of Michigan, below the Mason-Arenac line, 50 ft. may be considered far enough from center line for the placing of a 6-ft. fence. Above this line in the Lower Peninsula, most engineers seem to agree that 75 ft. normally is enough. There are, to be sure, exceptional locations in both places which would require greater distances than those given.

It is evident that the ordinary 66-ft. right of way will not permit of the use of permanent snow fences, either natural or artificial and that even temporary or removable snow fence must be placed on private property. In many sections of good agricultural land it is impossible to secure permission of the property owner to erect this fence where it is badly needed. The only solution of the difficulty which offers permanent results is the acquisition of a right of way sufficiently wide to permit of the use of a natural wind break as snow fence.

It might be argued that this wider right of way should be confined only to those places which are known to be bad snow catchers and limited to one side where it is necessary. Any one with any long experience in snow removal work will appreciate the difficulty of entirely anticipating places where snow fence is needed. A difference in the culture of adjacent property may materially change conditions from year to year. Brush land may be cleared up and put under the plow and produce a very bad situation in places where no trouble was ever heard of before. In many places in the state it is hard to even know positively on which side of the road to place the fence. While the prevailing wind direction may remain the same, a few storms may completely block the road from the side on which no fence was placed. The uniform width of right of way is a very much more attractive and easily maintained proposition and is for all the reasons stated the only scheme to consider. Fortunately for us in this state, in the northern part, where the widest right of way is necessary to permit the use of the natural wind breaks, land values are low and the right of way easily obtained.

The use of this wider right of way has many other advantages outside of the snow removal problem, but it is with this problem only that we are concerned in this discussion. The policy has therefore been adopted by the State Highway Department to secure 100 ft. right of way on all trunk lines south of Trunk Line 20, west of Clare, and south of Gladwin and Standish, with the exception of Trunk Line 11, which is to be 150 ft. right of way throughout its entire length. All trunk lines north of the line, Ludington, Clare, Gladwin, Standish, will be 150 ft. right of way.

The adoption of this policy will mean an immense saving in snow removal cost. Artificial snow fence is expensive to construct and maintain and, at that, no one has yet gone into the matter of drift prevention nearly as extensively as it is admitted is necessary. The natural growth along the wide right of way will serve this purpose and be far more attractive than the bare roadside during the summer months. Very little maintenance of this growth will be necessary. The elimination of the heavy drifts will permit of the use of lighter and faster removal equipment, which is very much cheaper to operate and gives a service incomparably better than that rendered by heavy tractor driven plows. This reduction in cost will mean the extension of service to many communities.



SNOW REMOVAL SCENES ON MICHIGAN ROADS

Snow King rotary plow being operated on trunk line west of Lansing in January, 1925; right rotor only being operated. Front view of plow under full load.

Front view of rotary plow, right rotor only being operated. Normal condition of plow being operated in solid snow bank; note lifting effect of nose of plow working into the bank.

Engineering in the Small City

A series of notes from the field on the Problems and Practices of the Municipal Engineer in the Cities Below 100,000

The Editor Visits the City Engineer

Snapshot of Our Representative Small Cities

STATE CAPITOL, MADISON, WIS.

Madison, Wis.

STATE CAPITAL OF WISCONSIN. Situated in Dane County, 80 miles west of Milwaukee and 135 miles northwest of Chicago, with two railroads to the former and three to the latter. Bus lines radiate over excellently maintained gravel and concrete road system to all points of the compass. Madison is a university town with a packing plant, sugar factory and several high grade manufacturing plants, including machine tools, battery works, gas engines. Settled in 1837, incorporated in 1856. Pop. (est. 1924) 50,000.

HOLDING an enviable record of years of being well governed and well managed from the engineering standpoint, Madison, capital city of Wisconsin, has always had alluring attractions for the engineer. With the engineering talent of the state university within its confines and a generous employment of outside consultants, especially in recent years, Madison has kept abreast of the times and progressed accordingly. Madison is largely a residence city. People who came to educate their children at the university, stay. The student body of 8,000 with the present summer schools is more nearly constant in size than formerly. Tourists are no small item, 1,500 foreign cars per day not being unusual.

As the encyclopedia would say, Madison, the four-lake city, is finely situated on a neck of land between Third and Fourth Lakes (Monona and Mendota). It is regularly laid out, the capitol occupying a central part of the city in a public park 70 ft. above the level of the lakes. Avenues 132 ft. wide extend from the center of each side of Capitol Square, and diagonal streets, upon three of which street-car service is maintained, run from each corner of Capitol Square, following the cardinal points of the compass, and cross the regular street system of the city at angles of 45 degrees. The university is one mile west of the capitol on hills about 125 ft. above the lake level.

Geologically, Madison is at the end of the driftless area of the glacial terminal moraine. Clay up to 8 ft. thick overlies sand and gravel. Running quicksand is not uncommon and in consequence all larger sewer mains are of cast-iron pipe. Trenching must be done carefully with attention to bracing and keeping water down by pumping. In the higher areas, however, excellent foundations are obtainable in the firm silty sand or gravel beneath the surfaces. In the excavation for the new 6-m.g. reservoir at an elevation of 200 ft. this fine sandy silt stands almost vertical in 15 to 30-ft. banks and shows no signs of disintegration even after several severe rain storms, bringing to mind the vertical loess banks at Council Bluffs, Iowa, which are ages old. With this character of drainage in the hills the ground-water level is nearly at lake level. Water supply comes not from the surface but by air-lift and motor-driven deep-well pumps from wells 800 ft. below lake level in the Potsdam sandstone stratum. The local sand is mostly too fine for building purposes and supply of both sand and gravel is obtained from Janesville or Beloit to the south. Crushed limestone for concrete aggregate comes from quarries at Waukesha. It has a high degree of frost resistance due to small absorption as tested by continuous freezing and thawing experiments on material in the sprinkling filters at the sewage plant.

Administration—For 70 years Madison has had a city engineer. E. E. Parker, the present incumbent, has been 13 years in the position except for a time during the war when he helped build concrete ships at San Diego. His staff consists of two assistants, two draftsmen, necessary rodmen and inspectors, the latter drawn from ranks of the older construction men. He reports to a board of public works, a non-salaried board with the engineer as the administrative officer, all appointed by the mayor and confirmed by the council of 20 members representing the 10 wards into which the city is divided. About $3,000,000 annually is spent by the board of public works which contracts for the work and levies assessments on both the property benefited and the city, the latter paying street intersections in all street work. Ten-year bonds are issued for the improvements, being a direct liability pro rata of the city and property owner. No bonds have ever been defaulted and the city easily disposes of the securities over the counter at prevailing high grade rates of from 4½ to 5½ per cent. The contractor gets cash monthly for 80 per cent of completed work and the balance on final completion and acceptance. Six years ago pavement guarantees were abandoned, materially lowering the bids. Force account work is done only on sidewalks, sewer laterals and small sewer extensions, water taps, services and meters.

Paving—In 1924, 6.02 miles of paving were laid, mostly reinforced concrete. This season 7 miles is the schedule, all of reinforced concrete. At the end of 1924 Madison had 95.42 miles of paved streets out of a total of 128.15 miles of streets. The various kinds and mileage are as follows: Macadam, 33.42; reinforced concrete, 20.15; sheet asphalt, 19.69; brick, 1.56; wood block, 3.57; tar filled macadam, penetration, 1.53; Topeka mix, 0.91; asphalt-filled macadam, penetration, 6.8; asphalt mixed (hot) macadam, 5.06; sandstone block, 0.1; asphaltic concrete, 2.63.

Of interest is the general use of reinforcing, a two-course pavement and combined curb and gutter with 1½-in. slope from outer edge of gutter to low point near the rounded base of curb face. For heavier trafficked streets, a 2-in. granite concrete top course is laid over a 6-in. gravel concrete foundation with 55 lb. of electrically-welded steel mesh fabric per 100 sq.ft. placed between the two courses. The base course is reduced to 5 in. on residence streets. Curb faces are rounded top and bottom. Steel plates as templets are set every 5 ft. against which screeds are used after the form for lower curve and 1-in. top coat in gutter has been placed.

Transverse expansion joints, ⅜ to ½ in. wide of tar felt, are placed every 33 ft. Maintenance, consisting of filling cracks with Tarvia X, is done in spring and fall.

Sewage—On completion of the plant under construction Madison will have built four sewage-works on three different sites, and abandoned two of them, all since 1889, besides having passed over four projects recommended by engineers from 1886 to 1897. This has been due chiefly to changes in the art of sewage treatment and to a lack of due allowance for the rapid growth of the city in population and built-up area—except that in the case of the first plant the city council threw up plans it had already adopted and accepted instead promoter-contractor plans for a proprietary process under guarantees that were not fulfilled. As accurately as can be stated in a few words, the second plant (1901) was designed by Prof. F. E. Turneaure, while city engineer, in accordance with general recommendations by Prof. J. B. Johnson; the third (1914-16) by John F. Icke and his successor as city engineer, Mr. Parker, with Alvord & Burdick as consulting engineers; and the latest one by Mr. Parker, with Pearse, Greeley & Hansen as consulting engineers. The fourth plant will be supplementary to the third.

All the plants have had as their main features tank treatment and filtration. Broadly, the tanks have been (1) chemical precipitation, (2) septic, (3) deep settling, with separate sludge digestion, and with secondary settling *before* filtration; (4) Imhoff, with secondary settling tanks and clarifiers *after* filtration. The filters have been (1) high-rate, partly "polarite" and partly sand; (2) double intermittent cinder, one above the other; (3) and (4) sprinkling, the filter medium being broken stone for both. When the new plant becomes overloaded, the intention is to aerate the tank effluent before it goes to the filter dosing apparatus.

Ample provision has been made to clear deposits from the underdrains by flushing or rodding. Seeding the filters with the special organisms found inimical to fly larvae will be practiced.

Overloading of the old plant is augmented materially by ¾ m.g.d. of packing house waste which is sixteen times as strong as the domestic sewage. The latter produces 4.4 cu.yd. of sludge of 95 per cent moisture per m.g. of sewage. Due to the overload the relative stability of the effluent has dropped to 69. The screens remove solids at the rate of 2.38 cu.ft. per m.g. and the grit chambers remove 5.59 cu.ft. The sedimentation tanks remove 98.1 per cent of the settleable solids, equivalent in dry sludge to 1.39 grams per capita per day. The cost of treatment alone is $5.34 per m.g., but pumping, maintenance, laboratory, interest and depreciation bring the unit cost of disposal to $18.89.

For years the popular notion of the layman in Madison has been that the sewage effluent was the principal cause of the odors which came periodically from Lake Monona. In 1920 an exhaustive investigation exploded this theory, laying the trouble largely to algae and decaying water weeds. A skilled chemist and biologist, in charge of the rivers and lakes, has been able this year by making frequent analyses to forestall any heavy growths with attendant odors by dosing with copper sulphate at the early period of growth. Removal of the weeds by cable attached to a truck which pulls the weeds out by the roots is thought more lasting than cutting with submarine saws.

Engineering Work

Water—Until 1916 the operation of the water-works was in the hands of the city engineer but his duties became too heavy and one of his assistants, I. A. Smith, was made superintendent of the water-works. However, Mr. Parker still has supervision of designs of new structures. Whether the sanitarily safe but hard well water should be continued as a supply or the soft lake water filtered should be used has been a serious bone of contention for years in Madison. The well water level is dropping rapidly 1 ft. per year and the engineers see the end. Between the biologists condemning the algae-laden lake water and bacteriologists loud in praise of the well water, the poor engineer has not much chance for his opinion. A 6-m.g. storage reservoir is being built to care for peak loads and new pump service installed, since the consumption varies from rates of 2 to 10 m.g.d. The reservoir will iron out the hourly fluctuations and permit an even pumping but in the meantime all industry and many householders are turning to softeners for the well water which contains nearly 300 p.p.m. of total hardness. Before designing the new reservoir, which is of the circular reinforced-concrete counterfort wall type, Mr. Smith looked up the technical journals and other literature on the subject. He found 125 descriptions of new reservoirs and descriptions of nearly half as many failures. With a 50 per cent chance of failure staring him in the face one cannot blame him for the extra steel, extra thick walls which do not depend on ring action and the ample provision for expansion joints at 50-ft. intervals around the 205-ft.-diameter circle.

Water is cheap in Madison, averaging about 6c. per 100 cu.ft. with a $2 service charge and a maximum rate of 7.5c. per 100 cu.ft. for the first 75,000 cu.ft. used in six months. The output costs of pumping per 100 cu.ft. in 1920 and 1921 were 5.88c. In 1922, 1923 and 1924 they were 5.55c., 5.49c. and 5.59c. respectively. All services are metered and the per capita consumption is about 100 gal. per day.

Garbage—In garbage Madison has experimented. Before the war, hog feeding, condemned by the State Board of Health, gave way to a 30-ton Decarie incinerator. It was used just three months when the national cry of waste brought back the hog feeders. Meanwhile the housewives had learned the sanitary advantages of wrapping and refused to do otherwise so now the city pays the hog feeders $1,500 per year to unwrap the garbage before the pigs get it. No other moneys change hands between city and feeders. In winter the paper is used for fuel to heat the garbage.

Zoning—Madison has been zoned for some time and likes it. The city engineer has nothing to do with it, but it affects his work inasmuch as his sewer and street plans are stabilized.

The personal calls on the city engineer's time, varying from a humble citizen who wants a sidewalk elevation changed to the mayor who wants to talk policy of big improvements or to the chemist who wants to see about a better method of cutting weeds in the lake, leaves little daylight time unoccupied. Mr. Parker meets them all smilingly and good naturedly. The human nature factor in this office has been solved and every one gets unfailing courtesy.

Of the Small City

Middletown's New Pavement Section Replaces Crown by Gable

By L. A. Waldner
City Manager, Middletown, Ohio

THERE has recently been completed at Middletown, Ohio, a concrete pavement which embodies several features hitherto unused in Middletown, noteworthy among which is the discard of a crown in favor of a section with a straight grade from the center to each gutter. Thickened pavement edges and staggered transverse expansion joints are other features. It is possible that this new design will be largely followed in an extensive paving program now under consideration.

The new design is the detailed section, shown in the drawing, "Typical Cross-Section for Concrete Pavement," and the one formerly used in Middletown is the other section with the same title marked "Void." The detail "Typical Cross-Section for All Streets Except Concrete," shows the base under all the other types. It is 8 in. thick with 10 in. at the gutter plate, whereas we formerly used 6-in. base under those types of pavement. The reasons for increasing the thickness are the increased traffic loads of modern times and the fact that we have been troubled with the base cracking which has occurred in all types of pavement. Experiment has shown that plain concrete of additional thickness is less subject to cracking than reinforced concrete of the thickness formerly used. However, it is necessary that attention be called to the fact that subgrade drainage is very important. Our local condition is excellent, for there is a stratum of gravel underlying and usually not over 30 in. from the surface, which is generally reached by the time the street is graded for surface drainage. It has been necessary, in some instances, to lay drainage tile in the subgrade.

The joints consist of a center joint, or predetermined crack running longitudinally throughout the street, expansion joints against the curb or gutter plate, the transverse joints about 60 ft. apart and staggered on opposite sides of the center. The center joint is of metal and has no provision for expansion. The expansion joints and transverse joints are a felt or pulp joint treated with asphalt. The transverse joints are 1 in. in thickness and the others are ¼ in. thick. If the pavement is poured in two operations, one-half the first time and the other half later, then it is possible to dispense with the metal joint and use a rail form at the center which can be made to form a wedge-shaped recess which will key to the second half. The rail fixes the screed form by which the pavement surface of the first half can be finished. However, it would be advisable to paint the first half with molten asphalt before the second half was poured, should the metal joint be dispensed with.

The method of drainage to the gutter plate which is usually accomplished by crown has been discarded entirely, and the cross-section is in the shape of a gable with a straight grade each way from the center to the gutter. This makes it possible to attain a surface which is very true to a straight-edge longitudinally if the gutter plate and center form are placed carefully to grade, whereas the old method of a crown usually resulted in an undulating surface which is very unsatisfactory and unpleasant to drive over. The height at the center was determined by the standard formula for the crown of a concrete street, namely,

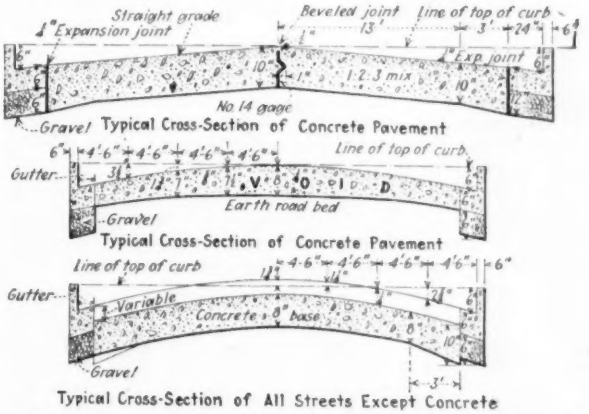
$$\frac{\text{width of roadway in feet}}{75}$$

equals height in hundredths of a foot which, substituting for a 36-ft. pavement equals 0.48 ft., which was so nearly 6 in. that six was used. This height, however, is more than is necessary on a street which has this gable cross-section as there is no flat place in the middle as occurs in the crowned street. The writer would therefore recommend the formula for this type be changed to

$$\frac{\text{width of roadway in feet}}{90}$$

equals height in hundredths of a foot, which would be 0.40 ft. or about 4¾ in.

This street has just recently been completed and it is



SECTION OF NEW AND OLD CONCRETE PAVEMENT AND STANDARD SECTION FOR ALL OTHER TYPES

impossible to state what action freezing will have on it. This, however, will be carefully watched and noted. The adoption of the gable cross-section has been very successful and undulation has been entirely avoided, as well as all possibility of water standing in the middle of the street. This often occurs in the crowned type, unless the crown is unusually high, and that should be avoided as it increases the skidding hazard.

Water Supply Improved by Covering Reservoir

Contamination of the water supply of Nacogdoches, Tex., by dust entering the small receiving basin located within less than 50 ft. of the tracks of two railway lines and almost as near to several industrial plant houses and two public roads was recently arrested by covering the basin, according to a paper by R. G. Upton, assistant engineer, State Board of Health, Austin, Texas, read before the Southwest Water Works Association. A series of bacterial tests showed a considerable percentage of samples containing B. Coli before the catchbasin was covered and a material reduction subsequently, as also a reduction in the total count of bacteria. Another reservoir forming a part of the water-supply system is now being covered. It is expected that this will result in further improvement of the supply and enable the State Board of Health to change its ranking of the supply from second class to first class.

Salvaging Old Streets by Asphalt Resurfacing and Oiling

Papers Presented to Asphalt Association Giving Details of Methods and Costs of Resurfacing Streets with Asphalt That Are Usually Lacking in Published Records of Street Improvement Operations

Seven papers of practical usefulness to the paving engineer are summarized here from the proceedings of the conference on asphalt pavements held in Detroit, Mich., Oct. 21-22, 1925. Chief emphasis was put by the conference on the resurfacing with asphalt of old pavements and rural roads. It is under this heading that the papers have been grouped here regardless of the time or the order in which they came up for consideration at the conference. A point to be noted is the wide range geographically of the experience related and the practical character of the experience data which are given. This practicality was evidenced in all the activities of the conference and papers and discussions generally contained very little that could not be laid hold of and put to actual use by street and road engineers. In explanation of the omission of the paper by G. C. Dillman on resurfacing gravel roads in Michigan, it is only right to say that the facts will be given in an article obtained in the field and prepared for early publication in Engineering News-Record.—EDITOR.

Resurfacing of Paved Streets at Columbus, Ohio

BY R. H. SIMPSON
City Engineer, Columbus, Ohio

FOUR types of old pavements have been resurfaced in Columbus, brick, boulders, stone block and macadam. About 72 per cent of the work has been on brick, 20 per cent on boulders and 8 per cent on macadam and stone block. In general it may be said that the results from stone block and brick have been uniformly successful and that in the case of the boulder pavements the results have been generally successful. The resurfacing over macadam has been of recent date, the oldest pavement having been laid in 1922.

The oldest paved roadway in the city of Columbus is Bryden Road, a street with a 40-ft. roadway which carries at present a traffic of 7,350 vehicles daily, 15 per cent of which are commercial cars. It is a sheet asphalt pavement laid in 1888 over boulders, and is, therefore, 37 years old. We have no record as to when the original boulder pavement was laid, but it consisted of a foundation of about 8 or 10 in. of crushed stone, the boulders being embedded in sand on top of this base. Coal tar pitch was sprinkled over the boulders before laying the asphalt, which was laid without a binder course. Two or three years later several other streets were laid in a similar manner, and, with one or two exceptions, the pavements are smooth and are giving good service today. In 1912 another old pavement of this type was resurfaced, but in this case a binder course was used and the pavement laid in the same manner as sheet asphalt.

The resurfacing over old brick pavements has been done in more recent years and there is definite information as to the details of the work and the construction methods. Practically all of these pavements were constructed between 1888 and 1892. They were laid on a macadam base, averaging about 10 in. thick, of crushed limestone, and there waterbound with crushed stone screenings. After rolling, a 2-in. cushion of sand was spread over this surface, on which was laid the brick, and the joints filled, in most all cases, with coal tar pitch. These old pavements have given good service, although there had been considerable repairs made on most of them and all had, for some years preceding resurfacing, a rough surface which did not meet the requirements of modern traffic.

All of the resurfacing over brick has been done only after a careful investigation of the subgrade conditions, as evidenced by the condition of the paving and the curbing. In any case where there was a question about the condition of the foundation, or the sub-base, actual excavation was made to determine, definitely, these conditions. If it was found that the curbing had become displaced by frost action, or that the brick in the surface had, in places, become displaced, from a similar or other cause, it was concluded that there was an unsatisfactory sub-base condition or a weakness in the foundation, or both, which, if extended over a considerable area of the improvement, would make resurfacing impracticable. In general it may be said that any pavement that has retained its general shape and contour for a period of ten or twelve years shows evidence of a satisfactory sub-base and foundation and that such a pavement may be resurfaced with a reasonable expectation of securing satisfactory results.

In preparing plans for resurfacing any pavement it has been the practice to take cross-sections at frequent intervals, which are platted on cross-section paper to any convenient scale. From these sections a new crown for the proposed surface is worked out which gives the required minimum thickness desired for the new surface. On account of the worn condition of the old pavement, these sections will probably disclose the fact that at certain points the old surface must be built up to form a satisfactory crown and where this condition is such as to require a thickness of 3 or 4 in. of binder, it has been the practice to place it in two operations, that is the low sections of the street are first brought up, with binder, to a crown 3 in. below that desired for the finished work, and then the surface is put on in the usual manner.

If the depth of the gutter in the old pavement cannot be reduced, safely, a strip of the paving 4 or 5 ft. wide is taken up and either a concrete foundation is laid at a lower grade, over which the asphalt surface may be laid, or a brick gutter is put in that will give the proper depth of the curbing and a shoulder 3 in. deep against which to lay the asphalt.

Drain tile has been laid on all street construction in the past 25 years, and in resurfacing, where tile was not used, originally, a 4-in. farm tile is laid 24 in. below the surface of the paving, just in front of the curb line, with outlets at catchbasins or sewer manholes. In many cases it is desirable to reset and recut the curbing in connection with resurfacing. This is not absolutely necessary unless it has been worn badly or forced out of position by frost action, but it adds to the appearance of the improvement and the cost is only a small per cent of the total.

The first step in construction is to excavate for the strip along the curb, lay the drain tile, reset the curb, if necessary, and lay the foundation strip along the curb, including the brick surface, if brick is used. The old pavement is then thoroughly cleaned with the use of water from a fire hose and men follow along behind with push brooms, sweeping the surface thoroughly to insure the removal of all dirt and foreign substances from the surface of the brick and the joints. After the pavement is thoroughly cleaned and dry, it is then ready for an application of the extra binder to bring the surface to the proper crown. When this is done the regular binder course and the top course are laid in the same manner as the laying of a regular sheet asphalt surface.

At intersecting streets it is necessary to relay a portion of the pavement on such street in order to meet the grade of the new work. If this is an asphalt pavement a portion of the old surface can be heated and removed and new top added, building it up to meet the new crown. If it is a brick or block pavement it is best to relay a number of rows of the brick or block at the proper grade to form a shoulder for the asphalt.

The resurfacing over stone block is done in about the same manner as over brick, the proper crown being mapped out and the surface laid as described above.

The first macadam pavement resurfacing was done in 1922 and the second in 1923, these two being the only pavements of this type resurfaced in Columbus. Both of these macadam pavements had been built for twenty years or more, with brick gutters along the curb, and the old curbing, brick gutters and macadam had shown evidence of satisfactory subgrade conditions. The macadam had a thickness of 14 in. The surface was scarified to a depth of 3 in. and the material removed, after which the surface was rolled to a grade that would permit laying 3 in. of asphalt and meet the shoulder of the brick gutter. These pavements have shown no evidence of weakness or wear and have required no repair since construction.

The problem of resurfacing a street containing car tracks is rather difficult of solution, unless the tracks are reconstructed. It has, however, been attempted on several thoroughfares in which the maintenance cost had been very heavy for several years, and on which it was the desire to improve the surface without the expense of reconstruction. This work was done by city forces out of funds appropriated from maintenance. In these cases a strip of brick about 12 in. wide along the outer rails of the car tracks was relaid at such a grade as to give a shoulder against which to lay the asphalt, and at the curb the thickness of the resurfacing material was reduced to 1 in. in order to give a proper depth of gutter. Asphaltic concrete was used on this work, the material being laid without a binder course, and to a depth of 2 in., except at the rail and curb where it was reduced to 1 in.

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Double-Seal Method of Resurfacing Macadam at Rockford, Ill.

By B. C. Harvey
City Engineer, Rockford, Ill.

OLD waterbound macadam streets which are beyond repairing by the surface-treating method are scarified to a depth sufficient either to raise or lower the crown and quarter points of the streets. The loosened base is then graded and thoroughly rolled, leaving a smooth and firm base. Stone ranging from 1¼ in. to 2½ in. is spread over the area to a depth of 3 in. This stone is then rolled and compacted enough to allow a heavy truck to drive over it without causing deep ruts. Bituminous material heated to a temperature ranging from 300 to 325 deg. F., using 110 penetration asphalt, is applied at the rate of not less than 1½ gal. nor more than 1.8 gal. per square yard. Stone ranging in size from ½ in. to 1¼ in. is then spread uniformly over the whole surface, filling all voids.

This course is then thoroughly rolled, leaving a firm, uniform surface. The roadway is then swept free from all loose particles of stone not held by the bituminous material. Then, not less than ½ gal. nor more than ¾ gal. per square yard of the same kind of bituminous material is applied, heated to the above described temperature. Stone ranging from ¼ in. to ½ in. in size is then uniformly spread over the surface. The roadway is then thoroughly rolled again. Then the same kind of bituminous material heated to the same temperature is applied at a rate of not less than ¼ gal. nor more than ½ gal. per square yard. Small gravel known as pea gravel is then uniformly spread over the surface. The surface is then rolled again until the bituminous material has a tendency to show through the gravel. This method has been found very successful, and after a few months of travel the streets look very similar to sheet asphalt pavement.

During 1924, 2.276 miles of streets were resurfaced, as described above and at a cost shown in detail below.

Rolling and scarifying, 1,060 hours at $1.50	$1,590.00
Grading roadway after scarified, 64 hours at $2.00	128.00
Labor spreading stone and building up subgrade, 3,132½ hours	190.21
Stone, 6,806½ cu.yd., delivered at $1.75	11,911.38
Gravel, 73½ cu.yd. pea gravel delivered at $2	147.00
Asphalt, 106,147 gal. applied at 11.5c. per gallon	12,206.92
Road oil, 5,000 gal. 45 per cent asphalt applied at 10.7c. per gallon	535.00
Total cost	$23,418.51

The number of square yards resurfaced was 40,995, and the cost per square yard was $0.693. The average number of gallons of asphalt used per square yard was 2.71. The bid price on 110 penetration asphalt was 10.98c. applied, and the bid price on road oil was 10.65c. applied.

During 1925, 0.653 miles of streets were resurfaced, as described above and at a cost shown in detail below.

Rolling and scarifying, 270 hours at $1.50	$405.00
Grading roadway after scarified, 61½ hours at $2	123.00
Stone loader, 22 hours loading stone and dirt	58.30
Truck service, 77 hours, hauling dirt at $1.50	115.50
Labor loading dirt, 78½ hours	49.47
Gravel, 52½ cu.yd. pea gravel delivered at $2	105.50
Stone, 1,322.22 cu.yd. delivered at $1.60	2,115.56
Labor spreading stone and building subgrade, 985 hours	631.95
Asphalt, 27,615 gal. applied at 10c.	2,761.50
Total cost	$6,365.78

The number of square yards resurfaced was 11,289, and the cost per square yard was $0.563. The average number of gallons of asphalt used per square yard was 2.44. The bid price on 110 penetration asphalt was $18.90 per ton f.o.b. Rockford.

In the costs as recorded above, interest on the investment of equipment together with the depreciation on the equipment is included. In the cost of the asphalt, car demurrage and cost of steam and clerical work are included.

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Resurfacing Gravel at Grand Rapids, Mich.

By C. A. Paige
City Engineer, Grand Rapids, Mich.

IN 1920, Grand Rapids had about 70 miles of gravel roads which were becoming almost impassable from the development of chuck holes. They could not withstand the increased automobile traffic and the maintenance cost was beyond the department's funds. Four streets of the above type were covered with a 3-in. sheet asphalt top in 1920, the first real venture in this type of paving. Since then there have been resurfaced 262,303 sq.yd. or 17.96 miles of gravel streets.

In preparing the gravel roadways for the asphalt top the street is scarified with a scarifier attached to and a part of the steam roller. This operation loosens the top layer of gravel, which is hauled from the street, only enough being saved for filling, where necessary, at the time of the subsequent rolling. The street is then thoroughly rolled with a 10 or 12-ton roller and brought to the proper grade to receive the 3-in. asphalt top. The street is then allowed to dry and the asphalt is applied as on a concrete base. Some old streets are so badly worn away that very little scarifying is necessary and new material is needed to bring them to the proper grade to receive the top.

If the old street was built with 3-ft., brick gutters, these are preserved and the asphalt built up to these gutters. Any bad depressions in the old gutters are eliminated by relaying the brick and the finished streets left in proper shape for good drainage. Where the street has combined curb and gutter, with an 18-in. brick border, these bricks are removed and the asphalt laid up to the remaining 18-in. concrete gutter. Any defective curb and gutter is replaced and again the street is left properly drained.

The gravel base has no apparent expansion or contraction —at any rate there is no movement great enough to cause cracks and develop imperfections in the asphalt top. In all the yards of asphalt laid on this type of base not one opening has developed from a base crack.

There are other points in favor of this type of pavement which should not be overlooked. Let us consider the cost of this pavement and speed in finishing as compared with one on a concrete base. If the gravel street were graded to a sufficient depth to receive a concrete base, the extra cost of excavation would amount to about $0.15 a square yard. The concrete base costs $1.10 per square yard. So, by utilizing the present gravel as a base, the property owner is saved $1.25 per square yard or from $1.50 to $2 per front foot of property, depending on the width of roadway. The gravel street is speedily prepared for the asphalt top and with but slight inconvenience to the public. There is no delay in waiting for the curing of the concrete and the public is permitted to drive on the gravel base as soon as it is dry and until the asphalt is applied. The majority of these pavements are laid in the residential districts,

where most of the gravel pavements were built. One in particular, however, is in the downtown district and carries a large amount of traffic. This pavement is in fine condition and has satisfied the city that this type of construction is the solution of the problem of salvaging the gravel road.

* * *

Methods and Cost of Oiling Macadam, Rockford, Ill.

By C. B. Harvey
City Engineer

THE surface-treating or oiling crew is composed of the superintendent of streets, who acts as supervisor, one foreman, who is also the tractor operator, two laborers, and four truck operators. The equipment consists of one 5-ton tractor, one stone spreader, designed by the writer and made by the street department, and generally four trucks, though on some occasions only three trucks are necessary, depending on the length of haul. Two of the trucks are owned by the city, and the other trucks are hired from the company from which material is purchased based on cost per yard delivered.

When macadam streets are to be surface treated, they are first thoroughly swept. The method of cleaning consists in sweeping the surface with two motor-driven pick-up sweepers. Two one-ton Ford trucks are used for hauling the sweepings to the dump. The two truck operators and two laborers clean all places not accessible to the sweeper and shovel all rubbish into the trucks and haul it to the dump. The cost of cleaning is charged against the street-cleaning fund. The average cost per 1,000 sq.yd. for cleaning all streets during 1924 was 41.48c. During the year 1925 up to Sept. 1, there have been cleaned 29,037,129 sq.yd. at a total cost of $11,615.95 or 40c. per 1,000 sq.yd.

The bituminous material is applied at a rate depending upon the condition of the surface of the roadway. The average rate of application during 1924 was approximately 0.15 gal. per square yard, and in 1925 the average rate of application was 0.22 gal. per square yard. Finely graded gravel, known as pea gravel, is then uniformly spread over the surface of the roadway by the stone spreader, which operates uniformly to a width of 8 ft. The stone spreader is drawn by the 5-ton tractor. The two laborers assist with loading the stone spreader and scatter extra gravel whenever necessary. The gravel is dumped directly into the stone spreader. We have surface treated as much as 27,232 sq.yd. of pavement in one 8-hour day.

During 1924 a total of 61.647 miles of macadam streets was surface treated, making a total of 1,113,826 sq.yd. The total cost for this work was $25,258.41 or a cost of $0.02267 square yard. The cost of cleaning streets prior to surface treating is not included in this cost. The cost of surface treating is figured as follows:

Oiling with Road Oil—Year 1924

Miles of streets oiled	0.534
Gallons of oil used — 2,425 gal. at 10.7c	$259.48
Number of square yards oiled	7,724
Cost per square yard	$0.0335

Oiling with 4-B Asphalt—Year 1924

Miles of streets oiled	0.253
Gallons of asphalt used — 1,300 gal. at 11.5c	$149.50
Yards of sand — 9 cu.yd. at $1	9.00
2 cu.yd. of pea gravel at $2	4.00
Labor spreading sand and gravel	18.60
Total cost	181.10
Number of square yards oiled	3,201
Cost per square yard	$0.0565

Oiling with 3-B Asphalt—Year 1924

Miles of streets oiled	10.95
Gallons of asphalt used — 32,824 gal. at 10c	$3,282.40
232½ hours labor	143.19
433½ cu.yd. of pea gravel at $2 delivered	867.00
77½ cu.yd. of No. 1 stone at $1	77.50
72 hours labor spreading and hauling stone and dust	144.00
63 cu.yd. of sand at $1	63.00
41 hours labor hauling and spreading sand	82.00
Total cost	$4,659.09
Number of square yards oiled	185,870
Average cost per square yard	$0.0250

Oiling with Tarvia B—Year 1924

Miles of streets oiled	49.91
Labor	469.89
Tractor	$260.25
1891½ cu.yd. of pea gravel at $2	3,783.00
130,545 gal. of Tarvia B at 12c	15,645.60
Total cost	$20,158.74
Number of square yards	917,031
Average cost per square yard	$0.219

Total Oiling—Year 1924

Miles of streets oiled	61.647
Total cost	$25,258.41
Number of square yards oiled	1,113,826
Average cost per square yard	$0.02267

It will be noted that different grades of bituminous material have been used for this work, the purpose being to determine which will give the best results. The materials used have been Tarvia B, Texaco 110 penetration asphalt, road oil and Indian Refining Co. 200 penetration asphalt. If all surface treatment had been applied on an 18-ft. roadway, it would cover a distance of 556,913 lin.ft., or 105.47 miles.

During 1924, for experimental purposes, after some of the streets had been thoroughly cleaned, the pea gravel was spread first, after which the Tarvia B was applied. From our observation the experiment has been successful and especially for a high-crowned street, as the gravel does not have a tendency to roll down toward the gutter.

Oiling with Tarvia B—Year 1925

Miles of streets oiled	22.90
Labor	$214.98
Tractor	116.00
700.1 cu.yd. of pea gravel at $2	1,400.20
73,933 gal. of Tarvia B at 12c	8,871.96
Total cost	$10,603.14
Number of square yards oiled	335,399
Average cost per square yard	$0.031

* * *

Reconditioning Macadam for Resurfacing, Springfield, Mass.

By W. H. Woodward
Superintendent of Paving, Springfield, Mass.

IT IS very seldom in city work that an old waterbound street is found in such a state as regards crown, grade and general surface condition as will allow the immediate construction of a bituminous wearing course upon it. When the finished grade may be raised and the old surface left untouched except for patching any depressions, the problem is simplified. However, more often a general reconditioning becomes necessary. Two conditions are met with: first, when the depth of the material is sufficient to allow for reconditioning, and second, where the subgrade must be excavated and the old macadam dropped in order to permit the wearing course to be at grade.

When the old waterbound has an adequate depth the procedure followed is first to scarify the street in such a manner as to disturb only as much material as is necessary to allow a true surface to be given it. The loose rock is reshaped by a scraper and any new material added where necessary. After this has been rolled, sand or trap rock screenings are used to make the base tight. The road is then sprinkled with water and rolled until firmly compacted. The base is ready for the wearing course.

There are many instances where it is necessary to lower the subgrade and drop the old macadam to provide for a proper thickness for use of it as a base. In this case the surface is scarified to the maximum depth possible. As it is necessary to remove the material entirely and dispose of it temporarily, a number of methods are employed. Where possible, the rock is picked up by a shovel and deposited on the tree belts. If not, it is removed and teamed to an adjoining street. Sometimes half of the street is constructed at a time and the other half receives the loose material. When the old macadam has been disposed of, the exposed subgrade is lowered to allow for the desired depth of rolled base. The excavated rock is moved to its position on the subgrade and the standard method of constructing a waterbound macadam pavement is followed. It might seem

that this method is expensive but such is not the case as machinery performs the major part of the operation.

This type of resilient base has given excellent results on streets many of which carry street-car tracks. The depth of the base is at least 4 in. and such a foundation carries a wearing course either of 2½ in. of penetration macadam or 3 in. of sheet asphalt. There are some penetration streets built in this manner which are twelve years old and some sheet asphalt about six years old. Judging from the service these streets render, it has proved good economy to utilize the old macadam streets for such a base.

* * *

Cost of Oiling Gravel Roads in Cuddo Parish, Louisiana

By J. T. Bullen
Parish Engineer

SINCE 1913 gravel roads in Cuddo Parish have been treated with heavy asphaltic oil at the rate of ½ to ¾ gal. a yard originally and then every 12 to 18 months with ¼ gal. a yard. Each oiling is covered with sweepings or sand. Care costs have been kept. They run from 5 to 8c. per square yard for first treatment, or $500 to $800 per mile on an 18-ft. surface. These costs include $30 per day for use of oiler, also the cost of sweepers, labor, foremen, trucks and covering material. The cost varies depending on length of haul, length of the stretch to be oiled and some other variable factors. Sometimes oil is taken over 40 miles from town and applied at not to exceed 8c. per square yard.

If this work could be continued over any regular period, using the equipment each day, these costs could be reduced considerably, but a mile, or perhaps 2 or 3 miles, are oiled in one job, and then operations are shifted perhaps to a point 50 or 60 miles away, where the next oiling is necessary. Typical costs are as follows:

Section I, Arkansas Line Road—24.2 mile post to 285 mile post 16 ft. wide. Oiled in 1922, at cost of $583 per mile or 6.4c. per square yard. Second application of oil Nov. 7 to sand for cover. Maintenance on this section for the nine months of 1925 cost $248 per mile.

Section K, Arkansas Line Road—8.4 miles; June 27, 1922; 14 ft. in width. Cost per mile $382; or 4.7c. per square yard, using per square yard 0.334 gal. This section maintained for nine months of 1925 for $200 per mile.

Mooringsport Road Section N—This was an old gravel road with gravel 4 to 6 in. in depth. In March 1922 from 3 in. to 4 in. of stone was added and 0.38 gal. of oil per square yard applied and in July 1922 a light coat was applied. The detail costs of first application are as follows:

1 Truck and sweeper, 1 day	$35.00
1 Truck and sweeper, 1 day	35.00
2 Oilers and helpers, 1 day each (at $30.)	60.00
1 Truck for men at $8	8.00
Labor 50 hr. at 22½c	11.25
Labor 100 hr. at 20c	20.00
Foreman 10 hr. at $8	8.00
2 Oilers 1 day each	60.00
Truck for men	8.00
Labor 50 hr. at 22½c	11.25
Labor 100 hr. at 20c	20.00
Foreman	8.00
Plant expense, 2 days at $15	30.00
Hauling sweeping from roadside, 2 days	75.00
4,400 gal. standard binder A at 8c	352.00
1½ miles	$741.00

1 mile, $593. 1 sq.yd. 0.06; Gal. per sq.yd. 0.38.
Maintenance, 9 months of 1925, $210.94.

Mooringsport Road, 3,700 ft. 18 ft. wide. First application Standard Binder A. 30 cu.yd stone and 30 yd. bank sand covering.

30 yd. rock $4.25 per yd. in place	$127.50
30 yd. bank sand $1.25 yd. in place	37.50
1 Oiler, 1 day	30.00
1 Truck sweeping and hauling men	15.00
Labor hand-sweeping and covering	31.75
Foreman	8.00
Plant expense	15.00
2,500 gal. standard binder A at 8c	200.00
1 Sweeper, 1 day	7.50
For 0.7 mile	$472.25

For 1 mile, $674.64; 1 sq.yd., $0.064; gal. per sq.yd., $0.34.
Cost of maintenance 1925 to date, 9 mo., $144.90.

Surface Treating Gravel Streets, Springfield, Mass.

By W. H. Woodward
Superintendent of Paving, Springfield, Mass.

THE METHOD favored is an initial coat of 45 per cent oil followed by treatments of 85 per cent asphaltic road oil. The surface of the road is first well scarified and then harrowed in order to break up any lumps and bring a maximum of stone to the top. The loose material is brought to a true shape by a road scraper and firmly compacted by a roller. Water is applied to the surface and the road again rolled. After sufficient time has elapsed to allow for the drying out process, ¼ gal. of 45 per cent asphaltic road oil is applied. This penetrates the gravel and acts as the sizing coat for the next treatment of ⅓ gal. per square yard of 85 per cent asphaltic road oil. A covering of coarse sand containing much gravel ranging up to ¾ in. in size is immediately thrown on and rolled until all the stones are forced into the road. Operations then cease until traffic has worked a maximum amount of sand into the asphalt. This is accomplished in about a week's time, after which any loose material is swept off and ½ gal. of 85 per cent road oil is applied. The same sand and gravel coat as before is spread and then rolled. The road is opened to traffic and great care is taken for at least a week to keep sand on the surface.

The use of sand containing gravel up to ¾ in. size as a covering appears to be very desirable. The stone, when rolled into the newly applied surface, is held in place from below and becomes an integral part of the underlying gravel. Further, this covering is not only held in place on the surface by the asphalt, but also being anchored, helps prevent any shoving of the bituminous material.

The cost of resurfacing miles of these gravel roads approximates 22c. a square yard. When one considers that some of this construction carries a traffic of upwards to 2,000 vehicles a day and has not been resurfaced for four years, it is adequate proof of the service rendered. The city favors the use of asphalt instead of tar for resurfacing gravel roads. Apparently the broken up crust of tar and gravel from previous treatments is objectionable and cannot be used to advantage in the new crust as the life of the material seems to be gone. With asphalt, the binding qualities endure, and new applications require less asphalt.

Federal Powers and Public Health

The Press Club of Chicago has found in the decision of Justice Lowell on the income tax payment of water-works employees, as reported in *Engineering News-Record* of Oct. 9, 1924, a possible new point in the right of Chicago to divert water from Lake Michigan and has prepared a resolution which it is submitting to a Chicago congressman in the hope that the matter may be of interest to Congress in enacting a possible law authorizing Chicago to divert the water from Lake Michigan. The paragraph in question from Judge Lowell's decision is: "That the National Government has no right, under the Constitution, to interfere with the sovereign powers of a state, or subdivision thereof, when they relate to a governmental function, such as preserving the public health. . . . The provision of a system of sewers has been held to be so connected with the public health as to be part of the governmental function of a municipality." The Press Club resolution then reads: "Assuming that the law laid down by Justice Lowell to be good law, your committee is encouraged in its belief that the Sanitary District is exercising its constitutional right to divert such water from Lake Michigan as is necessary to operate its sewerage system, and that the Federal Government has no jurisdiction as to the necessary *amount* diverted."

Concrete Pit Structure Subjected to Diverse Stresses

Provides Watertight Foundation and Inclosure for Rock Crusher—Copper Construction Joints—Winter Construction

By A. E. Wynn
Chief Engineer to G. W. Thompson, Engineer and Contractor, Syracuse, N. Y.

AN UNUSUAL type of reinforced-concrete structure was built last winter for the LeRoy Lime & Crushed Stone Co., LeRoy, N. Y., to provide a watertight foundation and an inclosure for a large stone crusher, placed 30 ft. below the bed of the quarry in a hole that was liable to fill up with water. Not only was the structure designed and built to resist this possible external hydraulic pressure, but concentrated loads of stone car trains on top of it and the jars and shocks from crusher operation and blasting had to be taken into account.

The quarry had been worked for many years, its bed being now about 30 ft. below grade. The crusher and bins were located at grade, so that there was a 1 per cent up-grade haul of 3,000 ft. for the dinkey engine in bringing the cars of stone from the bed of the quarry to the crusher. Since it was planned eventually to excavate the quarry to 60 ft. below grade, this condition was constantly becoming worse. The owners, therefore, decided to remove the crusher and place it below the present level of the quarry floor.

An excavation had already been made with this in view, but since there was no drainage outlet, it was filled at times with 30 ft. of water. This resulted in the decision to build a reinforced-concrete foundation and inclosure with walls sufficiently high to prevent any possibility of flooding. The structure as built consists of two parts, the lower portion nearly square and 30 ft. high to house the crusher itself, and a ramp with side walls extending from the top of the foundation up to grade, to inclose the belt conveyor which carries the crushed stone from the crusher to the bins. The bins remained in their original location at grade.

Design Considerations—The design of the structure presented several problems. The water displaced in the excavation weighed about 3,000 tons and since the weight of the structure was only 1,500 tons, anchorage to the foundation was necessary. This was done by grouting 1¼-in. square dowels into 4-in. diameter holes drilled 5 ft. into the rock. These dowels were bent over in the top of the slab and tied together at the bends with 1-in. bars to distribute the pressure. These bars also served to support the top reinforcement. It was thought that some bond could be obtained between the concrete and the rough limestone rock which had been well cleaned off and washed with cement grout before the foundation was poured. Allowing only 5 lb. per square inch in bond, this was equivalent to a small part of the uplifting pressure, so the dowels were proportioned for the remainder, the bond stress, however, being sufficiently low that if necessary the dowels could take the whole pressure.

The tensile stress in the steel was fixed at 12,000 lb. per sq.in., since it is advisable to keep this as low as possible in all watertight structures. In order to keep the percentage of reinforcement as low as possible, the extreme fiber stress allowed in the concrete was 500 lb. per sq.in. The foundation slab was designed for the uplift that would occur, assuming half the dowels to be ineffective. It was reinforced in the top from wall to wall. The lower end wall was reinforced as a slab between the side walls. The side walls were reinforced as vertical slabs between the foundation and a system of horizontal struts at the top of the walls. Near the top of the slope of the ramp section, as struts would have interfered with the belt conveyor, the walls were designed as cantilevers.

The crusher is fed from trains of stone cars that pass over the top of the structure. As the direction of the track changes, the rail would have to be carried on loose heavy timbers laid across the struts and the walls. These, therefore, had to be designed for heavy concentrated loads, in addition to both direct compression and bending. At all corners sufficient reinforcing steel was provided to take care of the maximum negative moments assuming complete fixation. Furthermore, as the whole structure was liable to considerable shock from heavy blasting in the vicinity, in addition to the vibration from the crusher and trains of stone, it was securely tied together with reinforcing steel so that it would act as a monolith. The compression face of all slabs and walls was reinforced against expansion and contraction by ¾-in. round bars, 12 in. to 18 in. on centers in both directions.

FIG. 1—WATERPROOF CONCRETE PIT FOR ROCK CRUSHING OPERATIONS

Struts carry railroad track from which cars dump directly into the crusher. The crushed rock is carried up the incline on a belt conveyor.

Waterproofing—Since the excavation already made was considerably larger than actually required, the structure would at times be completely surrounded by water. One of the first considerations then was to make the structure watertight. After considering several methods of membrane waterproofing, it was decided to rely mainly on the quality of the concrete itself with the addition of an integral waterproofing compound. Cracks were to be prevented by providing adequate reinforcing steel to take care of expansion and contraction, all pos-

sible bending moments, and shocks from heavy blasting.

The construction joints, where leakage was most likely to occur, were considered to be the vertical joints in the walls and the joints between the walls and the base slab. These were reinforced with 20-oz. copper baffle strips bent over on each side of the joint. All joints in the copper strips were soldered and vertical strips were soldered to the horizontal strips. No leakage was expected in the horizontal joint in the wall.

A very dense and homogeneous concrete was obtained by using crushed limestone aggregate with crushed stone dust in place of sand. The stone dust varied in size from dust to ¼ in., being well graded with little fine dust. The engineers had just completed a large reinforced-concrete bridge successfully using this same material instead of sand, the resulting concrete being very dense and exceptionally free from voids, in addition to presenting a uniformly colored surface. All concrete was mixed in the proportion of 1:0.2:0.4; the maximum specifications for adding waterproofing paste called for 10 lb. per cu.yd. of concrete.

Winter Construction—Since it was necessary to have the crusher ready for operation by April 1 and since the construction did not commence until the beginning of December, all work was carried on under winter conditions. One advantage, however, of building the structure in the winter was that the concrete was steam cured. All aggregate and water were heated and a line of steam pipes placed around the walls. In addition, the pit was covered from bank to bank with tarpaulins and live steam was kept in the inclosure day and night. Throughout most of the construction, the outside temperature was very much below freezing. The high walls were poured in two lifts and the lower part was stripped within 36 hr. after pouring; the exposed concrete however was surrounded by steam for several days. By thus keeping the surface temperature approximately the same as the interior temperature, and by reducing both slowly, cracks from initial contraction were prevented. The one horizontal construction joint in the high walls was covered with several inches of straw after pouring. When this was removed, the concrete was thoroughly cleaned before concreting proceeded.

A week after the high walls were completed and before the top struts were placed, a thaw set in, filling the entire pit with water. No harm was done to the walls, however, since the pressure was equal on both sides. The work was resumed in about 4 weeks and concreting was completed in 10 days. About two weeks later another thaw occurred and the structure was under the full head of water for several weeks. It, therefore, had an early and severe test. The only leakage noticeable was a little dampness on the inside of the walls at a few points where the tie wires had been. This was easily stopped by pointing the holes on the outside. The structure has been in use now for five months and has given complete satisfaction.

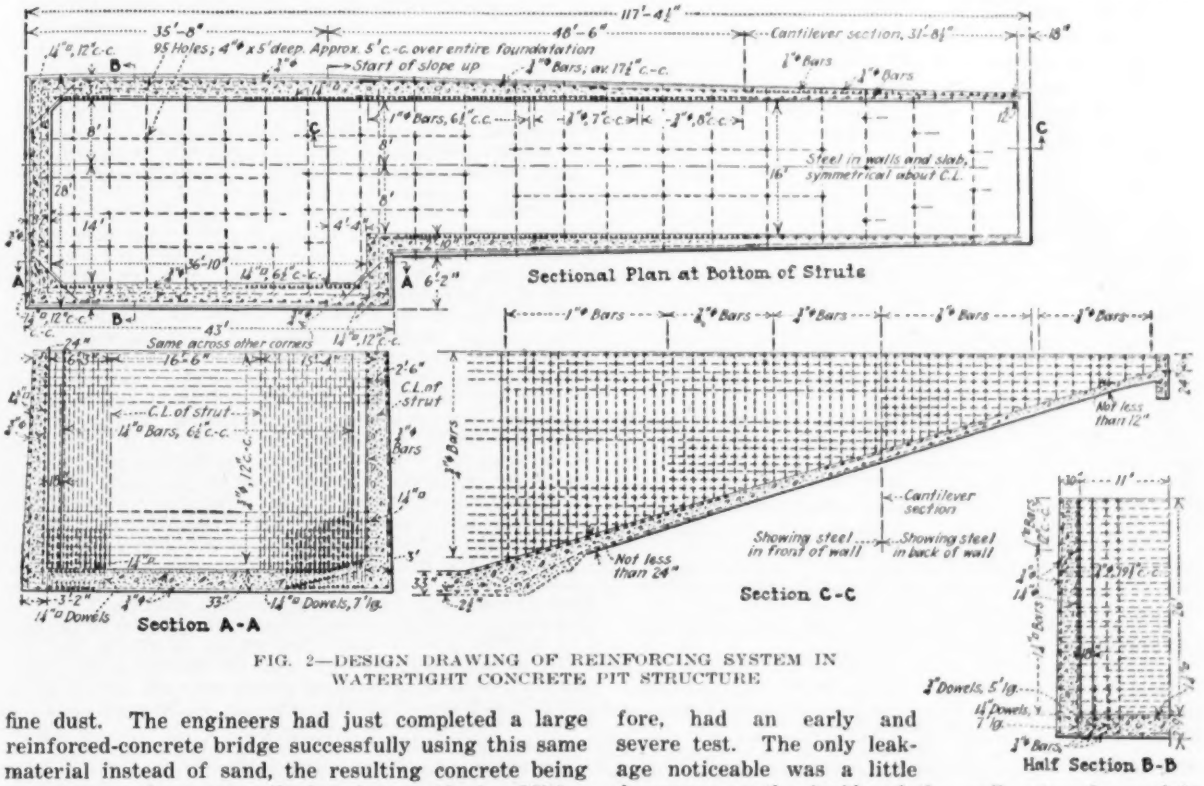

Sectional Plan at Bottom of Struts
Section A-A
Section C-C
Half Section B-B
Cantilever section
Not less than 24"
Not less than 12"
Steel in walls and slab, symmetrical about C.L.
Start of slope up
95 Holes; 4" ø x 5' deep. Approx. 5' c.-c. over entire foundation
Same across other corners
C.L. of strut
Showing steel in front of wall
Showing steel in back of wall

FIG. 2—DESIGN DRAWING OF REINFORCING SYSTEM IN WATERTIGHT CONCRETE PIT STRUCTURE

Engineers and Contractors—The structure was designed and supervised by G. W. Thompson, engineer and contractor, Syracuse, N. Y., for whom the writer is chief engineer, and Maurice Colle, superintendent of construction.

Expenditures of Argentine Highway Funds

A special division of the Ministry of Public Works of Argentina has been established to handle the funds derived from Law 5,315, under the direct supervision of the Ministry, says Commercial Attaché E. F. Feely, Buenos Aires, in a report to the United States Department of Commerce. Law 5,315 provides that all railroads operating in Argentina shall contribute 3 per cent of their earnings toward the construction of highways, bridges, etc. The average revenue from this source is 5,000,000 to 6,000,000 pesos annually.

Principles of Refuse Incinerator Design and Operation

Model Incinerator Specifications and Contract Tests Drawn by American Public Health Sanitary Engineering Section

SUGGESTED principles to be used in drawing specifications and contract forms for incinerator installations, and for supervision and report on acceptance tests, were presented in committee report Oct. 22, 1925, before the Sanitary Engineering Section of the American Public Health Association. These were basic principles covering the design, construction and operation of municipal refuse incinerators and were drawn for the general guidance of city officials and of engineers who do not specialize in refuse disposal. The committee personnel was C. A. Holmquist, chairman, John H. Gregory, M. N. Baker, Edward D. Rich, and Samuel A. Greeley. The principles follow:

1. For reasons of sanitation it is believed advisable to keep garbage and refuse in separate containers at the house. The collection, however, may be either separate or combined depending on local conditions.

2. Household and industrial ashes should not be incinerated but should be hauled directly to the dump or fill.

3. The revenue derived from salvage and utilization of municipal refuse will probably never equal the total cost of collection and disposal. The possibility of the utilization within the works of power generated by incineration of refuse is worthy of consideration.

4. In selecting a site for the location of the incinerator due consideration should be given to its accessibility for collection districts, the character of neighborhood as regards use and occupation, and its elevation with reference to the surrounding territory in order to minimize the possibility of nuisance.

5. Before specifications are drawn up certain fundamental data regarding the refuse should be obtained, such as total tonnage, relative proportion of the various constituents by weight and volume, calorific value, etc.

6. Specifications for the work should always be drawn up and should include the following points: (a) The plant should be planned for at least two units for flexibility and reliability of service and to facilitate making repairs. (b) Good engineering standards for materials of construction and quality of work should prevail. (c) The quality of fire brick used in the furnace should vary according to the demands in the different parts of the furnace, as to porosity, refractoriness, coefficient of expansion, hardness and ability to withstand abrasion. (d) The lining and arches of the furnaces should be so constructed as to prevent warping and cracking of the exterior walls. (e) The grates should be so designed as to make ample provision for expansion and contraction, to facilitate clinkering and to prevent overheating. (f) Suitable drying grates or hearths should be provided where garbage and other refuse having high moisture content are to be incinerated. (g) A combustion chamber of suitable size and arrangement to facilitate combustion and arrest dust should be provided. (h) If a boiler is installed to utilize the heat produced at the incinerator, due consideration should be given to the character and calorific value of the refuse in order that the boiler may be so located as to prevent undue cooling of the gases before combustion is complete. (i) Sufficient air, properly distributed to give complete combustion, should be provided. Forced draft with air preheated to not less than 300 deg. F. is desirable, especially in the larger plants. (j) Simplicity and ruggedness in design should be sought in all mechanical devices. (k) Proper means of charging the furnace, with special provision for preventing undue loss of heat and the escape of gases of combustion during charging, should be provided. (l) Where the type of furnace or the local conditions require temporary storage of refuse, the storage bins or containers should be so constructed as to facilitate ready cleansing and a minimum handling of the refuse. (m) Provision for rapid clinkering and for the disposal of clinkers and ashes should be made. (n) Suitable instruments for measuring and recording essential data and results of operation of various parts of the plant are desirable. The minimum equipment for larger plants should be a continuous recording radiation pyrometer, a CO_2 recorder, thermometers or pyrometers for recording the temperatures of chimney gases, preheated air and outside air, and draft gages for recording pressures in ashpits, flues and chimney. (o) Suitable scales should be provided for weighing the refuse delivered to the plant. (p) Ventilation of the plant should be provided in such a way as to prevent outside nuisance from odors or dust. (q) In general the plant should be so designed as to enable ready cleansing of floors and apparatus, and the necessary facilities should be provided for that purpose.

7. Each bidder should submit with his bid a list of two or more municipal plants operating successfully in the United States under conditions similar to those obtaining for the proposed plant and of the same pattern as the incinerator on which his bid is based.

8. Contract forms should be prepared and bids should be submitted in such a manner as to afford ready comparison of bids on unit prices of construction, and efficiency of operation, including annual charges of operation, interest and depreciation, under the stated guarantee.

9. The contractor should make certain guarantees of efficient and economical operation under bond covering the following points, and the final acceptance of the plant should be contingent on the results of a test run of not less than 10 days duration, conducted under certain specified conditions: (a) Personnel required to operate the plant for a given tonnage of refuse of a stated approximate percentage of constituent materials. (b) Net cost per ton for incinerating refuse containing certain percentages of water and combustible. Where additional fuel is needed for complete combustion, the maximum quantity of fuel required per ton of refuse (usually 200 lb. of coal or the equivalent of oil or gas per ton of garbage is necessary for complete combustion). (c) Number of pounds of refuse (of specified composition) to be incinerated per square foot of grate area, per hour. (d) Probable gross rate of evaporation in boilers from and at 212 deg. F. per pound of refuse (of specified composition) consumed. (e) Minimum combustion chamber temperature 1,250 deg. F. Average combustion chamber temperature 1,400 deg. F. (f) No smoke to be emitted from the stack of a degree of darkness or density greater than that shown by Chart No. 1 of Ringelmann's smoke scale. (g) No dust or noxious odors to be emitted from stack or plant. (h) All refuse, except metals and incombustible materials, to be evaporated and burned to a mineral ash practically free from organic matter. (i) The city to be secured against litigation which may be brought for use of any device or patented article included in equipment.

10. The method of conducting the final tests and the personnel of the committee of judges should be specified. (It is desirable that the contractor carry out a preliminary test for at least a 5-day period.)

11. The procedure to be followed in cases of failure of the plant to meet the requirements, should be specified. (Frequently the contractor is granted a 60-day period in which to make changes preliminary to a second and final test.)

12. During the preliminary operation and test periods all operations should be carried on by and under the control of the contractor, who should supply the supervision and all labor and fuel necessary for the operation of the plant. The municipality should deliver at the plant the refuse to be incinerated.

Sea-Gulls Make Reservoir Covers Necessary

Until recently distribution reservoirs in San Francisco have never been covered and no contamination of water so stored has been indicated. In recent years, sea-gulls protected by law have invaded the city and by frequenting the various reservoirs have made covers necessary. Not only are covers now included on all new reservoirs but as fast as possible covers are being put on all open storages.

The White Bluffs-Hanford Land Settlement in Washington.

One Hundred 20-Acre Irrigated Farms Use Water Pumped from Wells—Payments $18.40 per Acre per Year at Start

BEGINNING with an act of the Washington legislature in 1919 appropriating $500,000 toward the White Bluffs-Hanford land settlement project, a state aid colony has been developed on the Columbia River about 50 miles north of Pasco, Wash., and 20 miles east of Priest Rapids, which in 1924 contained one hundred 20-acre farm tracts. The land was selected expressly for irrigation. Before the settler goes onto his farm the state selects the location for a well or wells, sinks them and equips them with motor-driven pumps of sufficient capacity to supply the needs of the area included in the farm. Of the 100 tracts of the project 62 have thus far been colonized and developed in whole or in part.

The raw land was purchased by the state at an average price of $18.50 per acre. The soil is such that under irrigation a variety of crops can be raised. Abundant water is available at an average depth of about 36 ft. In order to secure this combination of fertility and available water together with topography suitable for irrigation it was necessary to scatter the groups of farms somewhat, and hence the tracts are not contiguous but are located in groups each containing several farm allotments.

Required qualifications of settlers are that the applicant shall have had some experience in farming and that he shall have at least $1,500 or its equivalent in credit. At first the project was open only to ex-service men, but this provision was modified when it was apparent that applications from ex-service men did not come in as rapidly as was desirable in order to settle the project. During the first few years in which the settlement was being developed the state maintained an office on the project in charge of J. C. Scott, project manager, who cared for the state's interest and who assisted the settlers in solving farm problems. Mr. Scott has had considerable previous experience, having been a county agricultural agent for several years. After the project was well under way and most of the lands had been properly planted to crop and otherwise improved this office was closed, thereby eliminating a considerable overhead operating charge. The project is now under the direct supervision of the state department of agriculture.

Each 20-acre tract is provided with one or more wells equipped with the necessary pumps and motors, served by the Pacific Power & Light Co. under a guarantee from the state that the power revenue shall be not less than $35 per year per horsepower of installed capacity for the four years following the installation of these motors. The pumping requirements of the tracts differ considerably, due to topography and lift, but the average capacity of the 102 motors installed is 5.5 hp.

In addition to the wells, the state constructs on each tract a 3-room plastered cottage with ample porches and concrete cellar, a 16 x 30-ft. combination barn and cow shed, and a small modern poultry house. Where the settler desires it, additional financial aid for clearing, leveling, seeding, fencing, fluming, etc., can be arranged for, and where necessary the state will pay the power bill for the first three years.

The total investment by the state in land, buildings, improvements and power bills (in cases where the settler elects to accept all financial aid available) amounts to approximately $5,000 per 20-acre tract. Toward this amount the settler is required to make an initial payment of $612.50. During the first three years of operation of the tracts it is assumed that this is a development period and for this reason the state requires only payment of pumping charges and interest upon the investment made by the state. Thus in the first three years the settler's annual payments amount to approximately $18.40 per acre, allocated as follows:

Interest on balance due state (4 per cent of $4,387.50)	$175.50
Power for pumping, $35 × 5.5 hp. (minimum)	192.50
Total	$368.00

Beginning the fourth year it is expected that the settler will have derived some return from the development of his tract and whatever is his balance at this time is amortized into twenty equal annual payments, amounting to $7.36 per year on each $100 of indebtedness, which constitutes an amount which will discharge interest and principal in twenty years. In other words this is the equivalent of an interest rate at 7.36 per cent on borrowed money without repayment of any principal. The average annual charge per acre is approximately $25.73 and on a 20-acre allotment is made up as follows:

Amortization of unpaid balance and interest due state (7.36 × 43.875)	$322.00
Power for pumping, $35 × 5.5 hp. (average.)	192.50
Total	$514.50

The settlement is favorably located with respect to markets, has an average growing season of 204 days, and according to government reports matures crops earlier than any other locality in Washington. The settlers now on the project are devoting about one-half of their acreage to feed for dairy cows, hogs and chickens and the remainder to early fruit and vegetables. During the first two years in which the project has been under way a great diversity of crops has been produced and the raising of stock and poultry has materially aided in stabilizing the income from the farms.

For information in the foregoing acknowledgment is made to an article published in *Journal of Electricity*, by H. W. Cooper, district manager, Pacific Power & Light Co., Pasco, Wash., and to supplementary information given direct by Mr. Cooper.

Mersey Tunnel Project in England

According to the Bureau of Foreign and Domestic Commerce, the select committee of the House of Commons, England, on July 28 passed a bill, promoted by the Liverpool and Birkenhead Corporations, for powers to construct a tunnel for general traffic under the river Mersey between the Lancashire and Cheshire sides. As the bill has been passed by a committee of the House of Lords, the way is now clear for the project. The tunnel will commence about 1 mile from the river bank on each side, with a gradual slope downward. Under the river bed it will be over one-half a mile in length on the level. The tunnel is expected to require five years to complete at a cost of about $25,000,000, of which the ministry of transport is to contribute one-half from the road fund. Work is to start as soon as possible.

Letters to the Editor

This department aims to be a forum for the discussion of the views of engineers and contractors. The range of interest should be as wide as possible. Contributors are, therefore, asked to make their letters short.

Temporary Hinges in Concrete Arch Ribs

Sir—It seems to me that the European method of designing fixed concrete arch ribs with temporary hinges is not sufficiently understood or properly appreciated on this side of the Atlantic. I note, for instance, in the review by A. Burton Cohen of W. L. Scott's book "Reinforced Concrete Bridges" (*Engineering News-Record*, Sept. 17, 1925, p. 479), the first presentation in English of this method is not overly emphasized or applauded.

The use of temporary hinges is advocated as a means of reducing the flexural stresses due to the elastic deformations in concrete arch ribs which will be fixed or hingless when completed.

The importance of doing away with flexural or bending stresses in concrete arch ribs has often been stressed by American engineers. In his treatise: "The Kinetic Theory of Engineering Structures," David L. Molitor says: "If an arch ring could be built in such a manner that its resultant polygon would pass through the center of the ring at the crown and springing points at the time of releasing the falsework, a large proportion of the redundant stresses could be prevented. In other words, the bending moment at the critical points would be then almost zero for symmetrical loading, reserving the strength for the unsymmetrical live-load and other contingencies affecting the shape of the arch ring."

The analysis of the elastic deformations of an arch rib shows that the material of which the rib is made is subject to an elastic shortening when the falsework which so far supported the rib is lowered and the rib placed under load.

Briefly stated, the elastic state of the rib under load is:

(1) The angular change at the end of the rib axis is equal to the angular change of the corresponding support.

(2) The length of the axis is equal to that realized during the construction and modified by the elastic shortening, the deformation of the supports, the shrinkage, and the variations of temperature.

The total work done in the rib under these assumptions is much higher than it would be if the work of the elastic deformations could be suppressed.

If the rib is hinged at the crown and skewbacks when the full dead-load is upon it and until the shrinkage effect is spent, a large proportion of the stresses due to the elastic deformations are suppressed because the hinges allow the rib to rotate under the influence of the stresses due to these deformations.

When the falsework is lowered, the crown joint moves downward through a small angle which can be computed. The resultant of the forces acting on the structure passes through the hinges, and the rib, when properly designed, is subject to uniform compression only.

At this stage, the rig under full dead-load is still a statically determinate structure and the computation of the dead-load stresses can be simply made by methods of static.

Continuity of the reinforcing can be obtained through the hinge gaps and when the temporary hinges are filled, the arch becomes fixed and the only bending stresses acting on it are those due to live-load and temperature variations.

The reduction of rib stress intensity obtainable with temporary hinge construction can be readily computed. In a parabolic rib having a rise ratio of $\frac{1}{5}$ and a depth at the crown of $\frac{1}{5}$ of the raise, the reduction of bending moment stresses obtainable is over 50 per cent of the total stress.

The various types of temporary hinges described in Mr. Scott's book have been used successfully in France for over twenty years. Professor Mesnager, of the French Institute, inspector general of the French Department of Bridges and Roads, who has had a long experience with this method, states that competitive bids always show a saving of 20 to 25 per cent in the cost of concrete arch bridges when this method is used, so much so that the older methods are now practically obsolete.

The data given by Mr. Scott on this subject are usually considered by the European designers to be part of their stock in trade and have not been available to the profession at large.

The method of temporary hinge construction offers means to build cheaper and longer concrete arch bridges than has been heretofore thought possible and its investigation is recommended to those interested in the design and the construction of concrete arches.

J. F. BRETT,
Consulting Engineer.

Montreal, Can.,
Oct. 17, 1925.

On Ethics of Engineering Competition

Sir—The correspondence between a certain state highway commission and a consulting engineer and your editorial comment thereon, in your issue of Oct. 22, are interesting. In general I am in accord with the views of the consulting engineer as well as those expressed in your editorial. There are, however, two points which I believe are worth further comment. First, I doubt if competition in the matter of engineering service is always wrong; second, the oft-repeated comparisons between legal and engineering practice are frequently not relevant. The first point is, perhaps, best illustrated by a concrete example.

A certain governing body, *A*, wanted to build a bridge with a movable span. It had its own competent engineering force capable of designing the bridge, which made all the necessary surveys, borings, etc. For reasons which are well known to most engineers it was, however, thought desirable to ask for propositions for the design of the movable span, which might be a swing bridge, a bascule or a lift-span. Is there any harm in asking two or more designers of such bridges for their terms for making such design and supervising the construction and then, assuming that the engineer or firm of engineers which submits the lowest figure is known to be competent, accepting this proposition?

It will be borne in mind in this connection that political bodies in democratic countries, even the most enlightened, do not generally favor the giving of contracts or the awarding of lucrative commissions of any kind without competition, and, however sound it may seem to be theoretically to pick out a high-class lawyer, architect, or engineer and turn him loose, it is probable that this without restrictions, in the present state of our political development, would not be entirely wise.

Now, what is the case in regard to lawyers? Because of their training and of the nature of their profession, they form the larger part of most of our governing bodies and administrators. They do not compete for work in the sense that they bid for it, but those who take an active part in politics and serve their political parties to advantage get as a reward such plums in the shape of lucrative assignments as are to be given out. I am not reflecting in the least on the manner in which they do their work. I believe most lawyers are as high-minded and conscientious as most engineers, and that's saying a lot. When, however, a judge has to appoint a receiver, an administrator of an estate, a master to hear testimony, or make any other similar appointment, he usually picks out a competent man, it is true, but he also usually thinks first if there isn't such a competent man among his friends or among the friends of his political friends.

I am not suggesting even that there is anything venial in this, but it seems rather tiresome to have the legal profession held up as the acme of perfection and as a shining light to be followed by the engineers in all matters of professional practice and ethics, and I haven't mentioned ambulance chasers, accident hounds, and others who I think have no counterpart among engineers.

This could, of course, be developed to a much greater length, but it will at least serve to indicate that there may be legitimate, healthy competition for engineering services within proper limits, that professional ethics for engineers cannot be wholly based on the professional practices of either lawyers or physicians, and that sweeping generalities are dangerous.

ETHICUSS.

Jersey City, N. J.
Oct. 26, 1925.

News of the Week

CURRENT EVENTS IN THE CIVIL ENGINEERING AND CONTRACTING FIELDS

Hearing on Boulder Canyon Dam at Los Angeles

Senate Committee Advised of Need for Flood Protection, Power and Water Supply

Special Correspondence

In a well arranged series of 30 papers, in which engineers had a leading part, Southern California on Oct. 26 and 27 presented a strong case for the early construction of a high dam at or near Boulder Canyon on the Colorado River in a hearing held at Los Angeles by the U. S. Senate Committee on irrigation and reclamation.

Mayor John L. Bacon of San Diego, president of the Boulder Dam Association—made up of 200 cities, county boards of supervisors, chambers of commerce, farm bureaus, etc.—and himself an engineer, outlined the general features and importance of the immediate construction of the Boulder Canyon dam for the combined purposes of flood control, de-silting of the river, irrigation and domestic water supply, and for power development.

Beginning with the critical flood-control situation in the Imperial Valley as pointed out by Earl C. Pound, president of the Imperial Irrigation District, who stated that it would not be possible by the levee system to protect the valley from inundation owing to the floor of the river rising about one foot per annum due to deposition of silt, and continuing through to the necessity of Los Angeles and other Southern California cities procuring domestic water, the hearing was filled with engineering facts, presented largely in non-technical manner, to convince the senators of the immediate and vital necessity of action.

Imperial Valley Problem

The silt problem in Imperial Valley was given detailed attention by W. J. Dowd, superintendent of the Imperial Irrigation District, who stated that the United States Government engineers had estimated the annual silt carried by the Colorado River as 90,000 to 100,000 acre-feet or as much material as was excavated from the Panama Canal.

The average amount of silt deposited in the district's canals was stated as 14,126 acre-feet, some years reaching as high as 24,920 acre-feet. In addition to the great expense of handling this silt it is becoming difficult to obtain sufficient lands along the canal rights of way to deposit the excavated material.

C. C. Frisbie, consulting engineer, Los Angeles, who has for many years made a special study of the All-American Canal project, compared the difficulty of constructing and maintaining this proposed canal through the drifting sand hills with that of the Suez Canal. He said that De Lesseps was confronted

(*Continued on p. 770*)

Engineering Fifty Years Ago

From *Engineering News*, November, 1875

Long Rails

DURING the recent celebration at Darlington of the fiftieth anniversary of the opening of the first passenger railway, the Britannia Iron Works Company, at their works at the neighboring town of Middlesborough, rolled for the inspection of visitors some rails of unprecedented length, and it is proposed to place one of them, 130 feet long, near the first locomotive engine, opposite the Darlington station, as a memorial of the jubilee. During the same week this company rolled in one mill, 1,350 tons of rails 40 lb. per yard, a quantity which it is believed has never been even approached in any other mill in the same space of time. The rails were for the New Zealand Government Railways.

Lake Chelan Power Permit Granted Railroad Interested

A permit for the construction of a hydro-electric power plant on the Chelan River between Chelan, Wash., and the Columbia River was granted to the Chelan Electric Co. by R. E. Tiffany, supervisor of hydraulics, state of Washington, on October 24. The Chelan Electric Co., controlled by the Great Northern R.R., has yet to secure a permit from the federal government since a part of the land to be overflowed when Lake Chelan is raised by a dam is on forest reserve areas. Although it is understood that the Washington Water Power Co. has not yet formally completed its contract with the Great Northern R.R. to absorb the Chelan Power Co., this plan is said to be under way preliminary to a contract whereby the Washington Water Power Co. would supply current for the Great Northern electrification project.

At the hearing a development of 100,000 hp. was mentioned and costs estimated to amount to $7,500,000 to $10,000,000 were cited.

Sewage Treatment Conference

The date of the seventh conference on sewage treatment, to be held at Iowa State College, has been postponed to Nov. 12, 13 and 14. The conference will be held in the Engineering Hall at the college at Ames, Iowa.

National Municipal Society Meets in Middle West

Elects New Secretary—Discuss Paving, Planning, Sewage and Contracts Forms

Meeting Oct. 26, 27, 28 and 29 at Des Moines, Iowa, in its thirty-first convention the American Society for Municipal Improvements elected a new secretary on salary, adopted specifications for concrete pavements which are to be sent out for letter ballot and by discussion arrived at a substantial agreement with the Associated General Contractors on a contract form. Street paving still continues as in the past, to be the principal feature of the technical program with sessions on city planning, sewage and garbage. While attendance at no single session mounted much above 100 a registration of 340 with an election of 75 new members indicates a liver interest in the organization than has been evident for the last five years. The officials are optimistic as to the future of the organization and with the added expenditures for secretarial help, are planning an intensive campaign for new members, particularly attempting to get in municipalities so as to stabilize the membership.

New Secretary

C. W. S. Sammelman, secretary of the Engineers Club of St. Louis, formerly principal assistant chief engineer, division of sewers and paving, department of the president of the St. Louis Board of Public Service, is the new secretary. He will continue to hold both positions. Carroll C. Brown, secretary for the last twelve years, insisted on being relieved since he has a full-time position as city engineer of the rapidly growing municipality of Lakeland, Fla. Mr. Sammelman was graduated from Washington University in 1906, holds a degree in law from St. Louis University, has been membership secretary of the St. Louis Chamber of Commerce, general manager of an automobile agency, handled the St. Louis convention of A.S.M.I. and has recently been engaged in the promotion of co-operatively owned buildings.

With the addition of a new section on design and minor changes as to arrangement the specifications for concrete pavements as submitted last year were adopted without discussion and ordered sent to letter ballot. They conform so far as materials are concerned with those of the American Society of Testing Materials, the A.S.M.I. committee headed by E. E. Butterfield, holding that their contribution should cover design and method of construction, accepting the A.S.T.M. standards without change. The specifications are an attempt to establish minimum requirements to meet average conditions

leaving to the engineer the determination of how far above these minimum requirements it may be necessary to go.

W. W. Horner, chief engineer of sewers and paving, St. Louis, and chairman of the committee on contract form, stated that the contract form of the Joint Conference of Engineering Societies, is nearing final approval but is not satisfactory for use in municipal work. The A.S.M.I. form, however, is to be made to conform with it insofar as is reasonably possible. The main contention seems to be the inclusion of an arbitration clause which many city engineers cannot include because it is not legal to do so. J. D. Ellison, vice-president, Associated General Contractors, said in 30 years experience he had had recourse to the courts but once and T. Chalkley Hatton instanced this fact and his own experience of 40 years with but three lawsuits as evidence of the infrequency of the need.

Ward P. Christie for the A.G.C. criticized mainly the legal phraseology of the A.S.M.I. form which the joint conference form has attempted to eliminate. The lawyers, he said, has involved the contractors and engineers in far more trouble than their own straight forward English would have done.

Street Paving

The technical papers on street pavements this year covered principally bituminous, concrete and brick types, with service conditions dominating. The later methods of apportioning asphaltic mixtures according to voidage and plasticity factor rather than bituminous content which has been developed from service observations as well as laboratory tests were fully discussed by Hugh W. Skidmore, president, Chicago Testing Laboratories with results of a new test for stability by Prevost Hubbard, chemical engineer and F. C. Field, chemist for the Asphalt Association. The test, which has had wide publicity in many recent meetings, consists of forcing a 1-in. cylinder of asphalt paving through a ring slightly smaller than the specimen.

R. H. Simpson, chief engineer, division of engineering and construction, Columbus, Ohio, presented a meaty paper on the relative costs for maintenance over long time periods of asphalt and brick paving which indicated in both types a material rise in annual costs about the twelfth year.

P. L. Brockway, city engineer, Wichita, Kan., a region where good aggregates are scarce, detailed a rattler test for 6-in. concrete spheres to determine abrasion qualities. He reported the tests indicated uniform wear on the balls and could be relied on to approximate service conditions.

Results of experimental roads in Queens after five years were outlined by E. E. Butterfield in charge of laboratories, Queens, N. Y. Surfacing dirt roads with cinders and asphaltic oils has proved satisfactory. Bituminous macadam with either trap rock, limestone or crushed gravel as mineral aggregate has not stood up under a procession of heavily loaded trucks but under moderate conditions has given good service. The same considerations with reference to mineral aggregates apply to asphaltic concrete. Three blocks of a key-block pavement after six years of heavy wear had a repair cost of $100.

City Planning

In the session given over to city planning, progress in execution was stressed by each paper and report. E. A. Fisher, consulting engineer, Rochester, N. Y., chairman of the committee on city planning detailed six major accomplishments since 1918.

The plan of Chicago was outlined in a paper by Eugene S. Taylor, manager, Chicago Plan Commission and that of Des Moines by James B. Weaver, member, Town Planning Commission. C. A. Taubert, acting secretary, Des Moines Zoning Commission, indicated the execution to date of the things noted in Mr. Weaver's paper covering streets, transit, transportation, parks and recreation, zoning and civic art. Harland Bartholomew, city planning expert, St. Louis, made the same kind of a report on accomplishments in St. Louis.

Sewage

Questions relating to municipal wastes covered sewerage, sewage treatment and garbage. Three papers related to sewers. A. L. Kurts, assistant engineer, Milwaukee Sewerage Commission, outlined the desirability and almost necessity for comprehensive plans for suburban districts on the same watershed as the city of which it ultimately will be a part. Methods of financing are more bothersome and were discussed in detail. St. Louis, Mr. Horner stated, makes a provision for the watershed and makes a levy against the property benefited outside the city limits, collecting when the area is annexed. K. C. Kastberg, city engineer, described the Des Moines problem and George M. Shepard, chief engineer, St. Paul Department of Public Works, presented an illustrated paper on timbering a sewer tunnel in sand and water-bearing gravel by the same methods used in the mines in the northern part of Minnesota by Finlanders.

Hans Pedersen, chief engineer, Iowa State Health Department and J. K. Hoskins, U. S. Public Health Service, spoke on stream pollution, the former of a survey of the Des Moines River and Mr. Hoskins of the limits and necessary treatment.

Preliminary treatment was covered by A. L. Fales, consulting engineer, Boston, and Dr. W. F. Mohlman, chief chemist, Sanitary District of Chicago. Both reviewed the various methods, compared screens and tanks and indicated preliminary aeration tank treatment is a coming procedure of value, particularly in raising rates or sprinkling filters, as much as three times the ordinary rate.

Sludge digestion as practiced in separate tanks was the subject of papers by L. R. Howson, consulting engineer, Chicago, and C. E. Keefer, engineer of sewage disposal, Baltimore. Mr. Howson covered the plants at Madison, Wis., Lincoln, Neb., and Great Lakes, Ill. Both reported success. Mr. Keefer reported better results than with an Imhoff tank, but he cautioned against adopting either without a technical prestudy. Mr. Howson stressed the same point remarking that separate digestion is particularly economical in first cost where deep tanks are difficult to build on account of quicksand or rock.

T. Chalkley Hatton, chief engineer, Milwaukee Sewerage Commission, showed two excellent, well-titled motion picture films of the Milwaukee plant which has recently gone into service.

Garbage collection was covered in three papers. W. J. Galligan, assistant superintendent of streets, Chicago, and R. E. Stoelting, commissioner of public works, Milwaukee, outlined in detail the change from horse-drawn to a motor truck-and-trailer service. Both concluded motorization a financial success. Paul Patton, garbage contractor, Kansas City, is of the opinion the cost of upkeep of trucks is not realized by cities. He recommends horse-drawn collection for short hauls with trucks and trailers for long hauls and mileage coverage. A balance between the two has been worked into an economy schedule at Kansas City.

Miscellaneous Papers

The Des Moines water works was described by Charles S. Denman, superintendent. A novelty is the installation of the first powdered coal equipment of the turbo-stage type automotically controlled in a water work plant in the United States. Preliminary tests indicated an increase in boiler rating of from 175 to 500 per cent.

Three papers dealt with street lighting, one on power plant development, one on public utility rates, one on day labor construction from the contractor's viewpoint, one on special assessment financing and another on how to eliminate irresponsible bidders.

The officers elected for the ensuing year are as follows: President, T. Chalkley Hatton, vice-presidents, C. R. Poole, J. B. Hittell and John Klorer; secretary, C. W. S. Sammelman, 3817 Olive St., St. Louis; treasurer, P. L. Brockway. As there is a desire to have at least one of the material association conferences meet during the same week, the A.S.M.I. place of meeting was placed in the hands of a committee with Memphis, Dallas and Columbus as suggestions.

An amendment to the constitution provides for the selection of the secretary hereafter by the executive committee which consists of the officers and all past presidents. A second amendment limits committees to seven members the majority of which must be active members. This opens the specification committees to the associate members.

Nearly 50 exhibitors had booths where models, samples, photographs and literature were on display. Educational features by the cement, asphalt, brick and granite block interests were shown as well as by the U. S. Bureau of Public Roads and City of Des Moines. Entertainment by the local committee headed by Monroe Patzig, included dinners, dances and a well-planned automobile drive over the city.

WASHINGTON NOTES

THE SECRETARY OF WAR has approved the application of the State Highway Commission of Alabama for permission to construct a bridge over the Tennessee River at Decatur.

A FULL head finally has been built up in the pool behind the Wilson Dam at Muscle Shoals and two generators can be operated at once. This will make it possible to deliver 50,000 kw. of hydro power for distribution in the Southeast.

A REPORT on the progress of the engineering investigation on the St. Lawrence was made Oct. 15 to the St. Lawrence Waterway Commission, of which Secretary Hoover is chairman. No matters of policy were taken up at this meeting which was called for the informal discussion of the engineering investigation. The members of the commission were impressed favorably with the progress the engineers have made. It was stated that no effort would be made to adopt policies until the engineers report next April.

ALL DEVELOPMENT of the water resources of the Colorado River and its tributaries, including the Gila, and every other stream in the basin, is to be suspended until the seven states concerned can agree. In the meantime James B. Girand, whose application precipitated this decision, has the encouragement of knowing that his rights will be the first one granted whenever the agreement between the states is reached.

The determination to take this action, it is presumed, took place at the cabinet meeting Oct. 27. It seems to have been the opinion to let the states of the basin understand unmistakably that they must reach some agreement among themselves before any development will be allowed to proceed throughout the vast territory drained by the Colorado.

Just at this time the decision is regarded by the opponents of the Girand license as a complete victory. Mr. Girand, while admitting great disappointment that his Diamond Creek development cannot be begun at once, sees in this decision a new assurance that he is certain to secure his license in time. While the wording of the Federal Power Commission's resolution calls for the suspension of all licenses "for a reasonable time," it is understood that the full intent is to make the period as long as may be necessary to secure agreement. In the resolution the opinion is expressed "that constructive governmental policy requires that the states affected should, and they hereby are earnestly urged to, reach as speedily as possible an agreement among themselves for the division of the waters of the river system, all to the end that thereupon development may proceed unchallenged upon interstate grounds."

New York State Approves Four Important Amendments

Early returns seem to indicate that the voters of New York State, by a small majority, have approved the four constitutional amendments submitted to them on Nov. 3. The first amendment is for a bond issue of $100,000,000 to be spread over a period of ten years to provide money for the acquisition by the state of real property and for the construction of buildings, works and improvements, chiefly for state hospitals, prisons, and educational institutions, and to provide housing for state officers.

The second amendment provides $300,000,000 for the elimination of railroad grade crossings. The cost of elimination is to be apportioned one-half to the railroad, one-quarter to the city, town or county affected, and one-quarter to the state. Money from the grade-crossing fund is to be loaned to the railroad companies and towns to be repaid in such manner as to carry interest and to amortize the payment on their portion of the bond issue. The state's portion of the cost will therefore be $75,000,000.

The third amendment provides for the simplification of the state government, the elimination of elective offices of secretary of state, state treasurer, and state engineer. It consolidates the 175 existing boards, departments, bureaus and commissions into 20 departments and prohibits the creation of new departments or permanent commissions.

The fourth amendment is for the improvement of the judicial system.

Lynchburg City Manager Dies

Edward A. Beck, city manager of Lynchburg, Va., died Oct. 18, following an operation for appendicitis. Major Beck was born at Peru, Ind., Jan. 19, 1885, and graduated in civil engineering from Purdue University. From 1906 to 1914 he was engaged in railroad engineering, being for five years a division engineer for the Wabash R.R. From 1914 to 1917 he was manager for the Borough of Edgeworth, Pa., and in 1917 became, jointly, manager for the adjoining borough of Sewickley. Resigning these positions, he became city manager of Goldsboro, N. C., which position he resigned in 1918 upon being commissioned a captain of engineers in the army. Upon discharge from the army in 1919 he became city manager of Auburn, Me., where he remained until in September, 1920, he became city manager of Lynchburg, Va.

International Road Congress To Be Held in Milan

Plans continue to go forward for the 5th International Road Congress which is to be held in Milan, Italy, Sept. 6-13, 1926. Any information regarding it can be obtained from the secretary, G. Lori, whose address is Via Sala 3, Milan, Italy.

Populous Counties Disapprove New Charters

Early election returns indicate that the proposed new charters for two New York State counties adjoining New York City, Westchester and Nassau, were rejected by a large majority in both counties.

Engineer Loses in Contest

George C. Andrews, water commissioner of Buffalo, N. Y., during the past 10 years, failed to win election as a member of the city council. Mr. Andrews, who is a civil engineer, ran on his record of having so administered the construction of the new filtration plant as to save $1,000,000 over the estimated cost.

Pennsylvania R.R. Prepares for Electrification to Wilmington

As a preliminary step toward the electrification of its line from Philadelphia, Pa., to Wilmington, Del., a distance of 28 miles, the Pennsylvania R.R. has begun the work of putting its telephone, telegraph and signal wires in underground conduits. No date has been set for the beginning of the electrification work.

Ontario Hydro Studied by Irish Government Officials

Patrick McGilligan, Minister of Commerce and Industry of the Irish Free State, and Gordon Campbell are visiting Canada under instructions from the Irish Government to secure information regarding the operation of the Ontario hydro-electric power system. A hydro-electric power plant to cost from $10,000,000 to $12,000,000 is now in course of construction on the Shannon River, and the Irish Government is anxious to obtain details of the distribution of power and administration of the Ontario system. The question as to whether the Shannon development will be operated under public ownership or by a private company has not been decided.

Scott Turner Appointed Director of the Bureau of Mines

Scott Turner, of Lansing, Mich., has been selected for the directorship of the Bureau of Mines and has been given a recess appointment by President Coolidge. He will assume his new duties Dec. 1. Mr. Turner is a graduate of the University of Michigan in 1902 and of the Michigan College of Mines in 1904. He has had a wide experience in the mining field throughout the Western States and in Alaska, also in Central and South America, in the tin mines in England and on the island of Spitzbergen. More recently he has been consulting engineer for the U. S. Bureau of Mines. During the war he served as a lieutenant, senior grade, in the Navy.

Damages Awarded in Chester Bridge Collapse Case

The first verdict for damages arising out of the collapse of the sidewalk of the Third Street bridge over the Chester River at Chester, Pa., on Sept. 10, 1921, (*Engineering News-Record*, Sept. 15, 1921, p. 462) was awarded last week when the jury in the case of Mrs. Hilda Knopf against the County of Delaware awarded her $3,120 damages. Mrs. Knopf's husband was one of 24 persons who lost their lives in the disaster. Her suit for damages is one of a number that have been pending in the courts for more than three years.

The Third Street bridge was a half-through plate-girder structure about 70 ft. in span, with the sidewalk supported by 12-ft. brackets cantilevered out from the girders and spaced about 12 ft. apart. The brackets were made of angle chords with a web system of four panels in the 12-ft. length and were attached to double stiffener angles of the plate girders by gusset plates at top and bottom. The collapse occurred when the upper attachment gusset of one of these brackets tore apart, allowing the bottom chord of the bracket to bend at its first panel point under the weight of a crowd that had gathered to watch attempts at the rescue of a boy from the water. When the sidewalk tipped down, some 75 persons were thrown into the water.

Examination of the ruptured gusset plate showed that it had torn off along the outer edge of the plate girder stiffeners. For a distance of 8 in. down from the top, the broken edge showed by a rusty surface that an old crack had existed in the line of the fracture and that the crack had worked progressively downward. The gusset was riveted to the top chord of the bracket but bolted, with five bolts, to the girder stiffeners. The corresponding plates of the other sidewalk brackets were riveted. The plate appeared to be wrought iron and to have the rolling grain running vertical. A canal boat had become wedged beneath the bridge in 1910 and had bent the bracket. It is said that repairs were made by straightening the plate without removing it from the bracket angles and the bracket was then replaced and attached by the bolts instead of rivets. Conflicting testimony about these repairs was given at the damage suit. One witness said the plate had been straightened by a sledge in the vicinity of the bridge, but the contractor who did the work testified that the bracket had been removed to a foundry for the repairs.

The county commissioners testified that they had made several inspections of the bridge, and Alonzo H. Yocum, county engineer at the time of the collapse, testified that he had inspected the bridge after his appointment in 1920 and again after repairs were made that year, and that he had found no defects. Counsel for the plaintiff, however, showed by expert testimony that a defect of the kind found in the gusset should have been plainly visible to an inspector and the collapse therefore showed negligence on the part of the county.

Highway Commissioner Quits in Disagreement Over Road Funds

James C. Creveling, highway commissioner of Tennessee, resigned on Oct. 21, in protest against the ruling of Secretary Jardine that unless Tennessee used part of its federal-aid road funds for the construction of a bridge across the Mississippi River at Memphis to connect with the Arkansas highway system, he would withhold further federal aid. Mr. Creveling objected to the use of Tennessee funds outside of the state. Subsequently, following a visit of Governor Peay to Washington, Secretary Jardine modified his ruling so that federal-aid funds will be available for road work and the bridge question will be considered separately.

Marin Water Bonds on Second Vote Carry 6 to 1

At a special election in Marin County (Calif.) on October 29 a $1,500,000 bond issue proposed by the Marin municipal water district carried by a vote slightly in excess of 6 to 1. The favorable votes totaled 4,462 while those opposed totaled 721. This water district includes the cities of San Rafael, Mill Valley, San Anselmo and adjacent territory.

Proceeds from the bond sale will be used to enlarge the present water holdings, build new pipe lines and serve the needs of an increasing population. A similar bond election a year ago failed to receive the necessary two-thirds majority.

Hearing on Boulder Canyon Dam Held at Los Angeles

(*Continued from p. 767*)

with the same objections that the canal could not be maintained on account of the wind-blown sand; the completed canal passes for 22 miles through similar territory to that traversed by the proposed All-American Canal and has had no difficulty whatsoever with the sand. Two dredges working only part of the time have kept the canal clear. Others urged upon the senators the necessity of this canal to save the river for American farmers on American soil.

The fact that the Imperial Irrigation District is already under contract with the government to make joint use of the headworks of the Yuma Irrigation District was cited by Charles L. Childers, attorney of the Imperial Irrigation District, who also stated that the district is compelled annually to execute a bond in the sum of $500,000 in favor of the government to guarantee against damage due to a temporary barrier by which they are enabled to divert Colorado River water into their present canals through Mexico.

R. W. Shoemaker, electrical engineer of the Turlock Irrigation District, stated that 40,000 to 50,000 hp. could be developed in drops along the All-American Canal, the sale of which power substantially would pay the fixed charges on the construction of the canal.

The need for a high dam to regulate the river for irrigation purposes was emphasized by Mr. Dowd, who stated that last year for 74 continuous days, Aug. 16 to Oct. 30, the Imperial Irrigation District diverted the entire flow of the Colorado River, and that during nearly all of this period there was a shortage of water, the flow at one time falling as low as 254 sec.-ft. entering the United States to supply the 400,000 acres under cultivation north of the border, there being roughly 200,000 acres in cultivation in Mexico.

William Mulholland, builder of the Los Angeles aqueduct, his chief assistant, H. A. Van Norman, former city engineer of Los Angeles, and A. L. Sonderegger, consulting engineer, gave data to show the critical need of Southern California cities for a safe, dependable water supply, which can only be secured from the Colorado River. Mr. Mulholland described the proposed 260-mile aqueduce with intake in the Colorado River above Blythe. It is proposed to take this water from infiltration ditches or galleries sunk in coarse gravel some distance away from the river, to procure water free from river silt. Los Angeles is now sinking wells and excavating trenches to test out this method of obtaining clear water. It will be necessary to lift the water by means of pumps over a summit against a total head of 1,600 or 1,700 ft. With the cheap power estimated to cost 0.33 to 0.4c. per kilowatt hour from the Boulder Canyon dam, this lift will not be prohibitive and is favored by Mulholland and other engineers of Los Angeles who have studied the project in comparison to a gravity aqueduct which would take out of the river some 200 miles upstream at Bridge Canyon as suggested for investigation by E. C. LaRue in Water Supply Paper No. 546, just published by the Geological Survey.

Mr. Van Norman's estimate of the cost of the gravity project is $540,000,000 as compared to $150,000,000 for the pumping project, the per capita cost for the pump project being substantially the same as that of the Owens River aqueduct was at the time construction was inaugurated by Los Angeles.

Southern California, Arizona and other districts immediately can place the entire output of 600,000 hp. available at the Boulder Canyon dam, Mr. Scattergood stated, and his view was concurred in by Senator Ashurst and others present.

During the hearing each of the senators showed his own keen interest in the project by asking many questions both of engineering, economic and political nature. Senator Pittman called attention to the general feeling throughout the United States, particularly in the East, against the reclamation of lands, which brought forth assurance by the mayor of Los Angeles and the representatives of many other Southern California cities that they were prepared to pay directly or return to the government the proportion of the cost of the Boulder Dam which might be represented by any allocation of power which might be made to these communities, thus guaranteeing the financing of the project.

Construction Conference To Be Held in Chicago

A conference of all contractors and others interested in the labor problem of the construction industry has been called by the National Association of Building Trades Employers. The conference is open to all interested parties whether affiliated with the association or not. It will be held at the Congress Hotel, Chicago, Ill., on Tuesday, Nov. 17, 1925. Invitations have been sent to the leading local, state and national organizations in the industry with the request that they send representatives to discuss the labor problem and to interchange ideas and information.

Among the questions which will be discussed at the conference are: Wage rates for 1926 in the building trades, availability of labor and results of the apprentice training movement, the five-day week in the building trades and the building outlook for next year. A similar conference was held in Cleveland last year.

Engineering Societies

Calendar

Annual Meetings

CITY MANAGERS ASSOCIATION, Lawrence, Kansas; Annual Convention, Grand Rapids, Mich., Nov. 17-19, 1925.

AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS, Washington, D. C.; Annual Convention, Detroit, Mich., Nov. 18-20, 1925.

HIGHWAY RESEARCH BOARD, NATIONAL RESEARCH COUNCIL, Washington, D. C., Annual Meeting of the Highway Research Board, Washington, D. C., Dec. 3-4, 1925.

AMERICAN ROAD BUILDERS ASSOCIATION, New York City; Annual Convention, Chicago, Ill., Jan. 11-15, 1926.

ASSOCIATED GENERAL CONTRACTORS OF AMERICA, Washington, D. C.; Annual Meeting, Portland, Ore., Jan. 18-23, 1926.

AMERICAN SOCIETY OF CIVIL ENGINEERS, New York City; Annual Meeting, New York City, Jan. 20-22, 1926.

ENGINEERING INSTITUTE OF CANADA, Montreal; Annual Meeting, Toronto, Ont., Jan. 27-29, 1926.

AMERICAN CONCRETE INSTITUTE, Detroit, Mich.; Annual Meeting, Chicago, Ill., Feb. 23-26, 1926.

Personal Notes

PROF. S. S. STEINBERG, of the University of Maryland, has been appointed assistant director of the Highway Research Board, National Research Council, Washington, D. C. Professor Steinberg for the present will continue to serve as acting secretary of the investigation on the development of earth roads now being conducted by the board. PROF. H. F. JANDA, former assistant director, has been designated secretary to the research committee in accordance with the new policy of the board to employ technical assistants who shall devote full time to research committee work. Professor Janda will return to his duties at the University of North Carolina on Jan. 1, 1926, at the expiration of his leave of absence.

GARDNER S. ROGERS, city planning engineer to the Milwaukee land commission, has resigned and will enter private practice as city planning engineer at either Sanford or Orlando, Florida.

FRED H. COOK has been appointed chief hydraulic engineer for the Holyoke Water Power Co. to fill the vacancy caused by the death of Albert F. Sickman, Oct. 17. Mr. Cook has been with the company since 1884, and has been assistant hydraulic engineer for 31 years. The position of assistant hydraulic engineer is filled by ALLAN W. LADD, a graduate of Union College, who entered the company's employ five years ago.

WALTER T. HORN, Indianapolis, Ind., an engineer for the public service commission, has been appointed engineer for the state tax board, succeeding HARRY V. WENGER, who has resigned, effective Nov. 1. Mr. Horn is a graduate of Purdue University.

SIR ARTHUR WATSON, formerly general manager of the London & Northwestern Ry., and also of the Lancashire & Yorkshire Ry. previous to the amalgamation in 1922, has been appointed general manager of the Buenos Ayres & Pacific Ry. in South America. Sir Arthur is a civil engineer who gained his early training under the late William Hunt, chief engineer of the Lancashire & Yorkshire Ry.

THE HUNTING-DAVIS CO., architects and engineers, Pittsburgh, Pa., announces change of firm name to HUNTING, DAVIS AND DUNNELLS, INC., C. G. Dunnells, professor of building construction, Carnegie Institute of Technology, becoming vice-president and chief engineer of the new organization. A new service is inaugurated as consultant in all branches of structural engineering. E. N. Hunting is president, L. N. Davis is secretary and treasurer of the company.

CHARLES H. ENSIGN, architect and engineer, Cleveland, Ohio, formerly of the firm of Ensign & Snow, Engineers which was recently dissolved, announces that he has opened offices for the general practice of architecture and engineering at 501-505 Fidelity Mortgage Building, Cleveland.

GEORGE H. WILLITS of Mexia, Texas, and his brother, WALTER W. WILLITS, of Saginaw, Mich., have formed a partnership for the construction of concrete foundations and bridges, with offices at 1011 Cass Ave., Bay City, Mich. Walter Willits has been engaged in this work since 1918 building bridges for the state of Michigan. George Willits has been with the engineering department of the Pure Oil Co. at Mexia, Texas, for the past year and previous to that time was city engineer at Galveston, Texas, and later construction engineer for the Mexican Petroleum Corp. at Galveston in the construction of their large oil storage stations at that point.

Obituary

GEO. M. BASFORD, railroad engineer and publicist, died suddenly at New York City on October 26 in the 60th year of his age. Mr. Basford was a native of Boston and a graduate of Massachusetts Institute of Technology in the class of 1889. After graduation he entered the Charlestown shops of the Boston & Maine R.R., later going to the Chicago, Burlington & Quincy as a draftsman at Aurora, Ill., then to the motive power department of the Union Pacific and subsequently to the Chicago, Milwaukee & St. Paul as signal engineer. Early in his career he took an active interest in railroad signaling and was frequently known as the father of the Railway Signal Association. He was also much interested in locomotive design and during the greater part of his career was very active in the promotion of improvements both in locomotives and in railway signaling. In 1895 he became mechanical department editor of *Railway and Engineering Review* and two years later became editor of the *American Engineer and Railroad Journal*, now the *Railway Mechanical Engineer*. In 1905 he was made assistant to the president of the American Locomotive Co. and in 1913 became chief engineer of the railroad department of Joseph T. Ryerson & Son. Leaving that company in 1916 he organized the G. M. Basford Co. to handle railway technical advertising.

HARRY A. BELDEN, formerly of New York City, consulting and railway engineer who had given considerable service in the Philippine Islands, died Oct. 30 at his home in Margaretville, N. Y., aged 60 years. Mr. Belden was student for a year, 1886-7, in Case School of Applied Science, and then engaged in drafting, construction and consulting work for various electric railways, in Baltimore, Washington, D. C., and New York City. In the same line, he was in charge of construction in Central America for the firm of C. G. Young, engineers, in China for Shewan, Tomes & Co., and in the Philippines for J. G. White & Co., Inc. Among the undertakings Mr. Belden had charge of were construction of electric plants and consultation on electric tramways in Hong Kong, China; street railway work in Manila and trolley lines in Porto Rico.

H. KENT DAY, Philadelphia, Pa., widely known architect, died Oct. 20 at his home in that city, in his 74th year. Mr. Day's firm designed campus buildings at Wellesley College and Cornell, Yale and Princeton Universities.

From the Manufacturer's Point of View

A Point of Contact
Between Maker and User of
Construction Equipment and Materials

Trade Associations—Their Activities and Problems

Academy of Political Science Devotes Annual Meeting to Conference on Trade Associations

THAT the trade associations still have their problems and responsibilities despite the recent favorable ruling of the U. S. Supreme Court in the cement and maple flooring manufacturers' cases was a subject dwelt upon by practically every speaker at the annual meeting of the Academy of Political Science in the City of New York held Oct. 28 in New York City. The meeting was devoted to a national conference on trade associations and business combinations and the eminence of the speakers and their ability to deal with the subjects assigned them will make a copy of the Proceedings containing their addresses and discussions of value to engineers interested in this particular problem. The Proceedings can be obtained by addressing the Academy at Kent Hall, Columbia University, New York City.

Warning to Associations — The ruling of the Supreme Court has resulted in an era of good feeling toward trade associations, a condition that their members and officers must foster by keeping within prescribed lines; this was a warning voiced several times. Although the existence of a gentlemen's agreement was disproved in the recent important cases, the danger that such charges can still be brought against associations still exists.

That trade associations by doing for themselves what they have long felt the government must do for them can help to reduce bureaucracy in the government was the contention of one of the speakers. American manufacturers, when confronted by business depressions, can profit by following the example of European manufacturers, who if anything co-operate more when business is bad than when it is good. It had been this speaker's experience that American manufacturers keep their problems too much to themselves during times of such economic distress.

Statistics for the Buyer — Most of the speakers discussed the control of fluctuations in the business cycle by making it possible for the producer, dealer and consumer to operate from the same information embodied in statistics. The producer and even the dealer are fairly well provided with helpful information but the buyer is still woefully lacking. If he could have information as to current sales, stocks on hand, etc., his operations could be put on a more intelligent basis and the ups and downs of the business cycle caused by lack of knowledge of supply and demand could be reduced.

The suggestion was made that the publication by the government of statistics showing investment, and rate of return by industries would tend to direct investing capital into the most necessary channels.

HOLDING COMPANIES

Holding companies as existing in the public utility field came in for considerable discussion at one of the sessions. Different speakers contended that they should and should not be under government control. It was said that they should not be controlled since they are merely stockholders the same as any investor. This speaker felt that the control exercised over the operating companies is sufficient. The danger of pyramiding holdings by which a company, by means of a comparatively small investment controls millions of dollars worth of utilities was cited as the main reason why control is necessary. The present tendency toward wide diffusion of holdings caused by many small investors was claimed to be an aid to minority control. Proxies are hard to obtain and an industry can often be dominated by holding only 20 to 30 per cent of the stock. Also recent examples of the purchase of industries by banking houses and syndicates who subsequently have issued many shares of non-voting stock, vesting the control in a relatively small number of voting shares was cited as a practice that should be possible of control.

A statement that was strongly opposed by several present was that the necessary governmental control should be obtained by giving to the existing Federal Trade Commission powers over business combinations similar to those enjoyed by the Interstate Commerce Commission over the railroads.

In the end, however, it was agreed that the holding company has done a great deal for public utility development by providing the new capital necessary for the rapid expansion that has been necessary.

Clay Products Research To Be Discussed

A program of research for the clay products and ceramics industries will be discussed at a conference to be held at the Department of Commerce, Washington, November 6. The following have been invited: H. J. Lucas, Chicago, National Terra Cotta Society; E. B. Adams, Alton Park, American Face Brick Association; William Schlake, Chicago, Common Brick Manufacturers Association; B. C. Keeler, Mason City, Iowa, Hollow Building Tile Association; F. B. Lawrence, Newell, W. Va., United Potters Association; C. E. Jackson, Wheeling, W. Va., American Vitrified China Manufacturers Association; F. W. Butterworth, Danville, Ill., Clay Products Institute; G. C. D. Lenth, Chicago, Clay Products Association; H. D. Shelly, Philadelphia, Eastern Clay Products Association; Frank Ferguson, Alton, Ill., Glass Containers Association; R. T. Hutchins, Cleveland, National Paving Brick Manufacturers Association; F. W. Walker, Beaver Falls, Pa., Associated Tile Manufacturers; E. Tillotson, Pittsburgh, American Ceramic Society.

Industrial Advertisers Meet

Cutting the high cost of selling by applying common sense methods to advertising and advertisements was the central theme which formed the pivot for discussions at the fourth annual convention of the National Industrial Advertisers Association at Atlantic City, Oct. 19-21.

Outstanding speakers included Julius S. Holl, president of the association; Bruce Barton, president, Barton, Durstine & Osborn; F. J. Petura, general purchasing engineer, H. L. Doherty & Co.; T. H. Dauchy, assistant sales manager, International Nickel Co.; Edward F. Carley, advertising manager, explosives department, E. I. du Pont de Nemours & Co.; Malcolm Muir, vice-president, McGraw-Hill Co., and E. J. Mehren, vice-president and chairman of the editorial board of the McGraw-Hill Co.

Business Notes

ROCK ASPHALT CO. OF AMERICA started operations Oct. 19 at a 2,000-ton rock asphalt plant situated on the Green River, Edmonson County, Kentucky. The company has principal offices in the Inter-Southern Office Life Building at Louisville, Ky., with W. E. Massey, president; O. M. Long is general manager at Bowling Green, Ky. The company had 3,000 acres of Kentucky rock asphalt thoroughly developed by open pitting and diamond drill coring before the erection of the plant. Geological surveys and reports indicate a tonnage of from 75 to 100 million tons of commercial rock asphalt in a vein averaging 25 to 30 ft. thick and with an average overburden of from 12 to 15 ft. Electrically driven machinery of the latest type has been used. The product will be shipped by barge to Bowling Green, Ky., and to Evansville, Ind., from which points it will be reshipped by rail to consumers.

F. M. CROSS, formerly manager of the pneumatic tool department of Ingersoll-Rand Co. in New York, has been appointed manager of the pneumatic tool department for the Chicago territory with headquarters at Chicago.

HEIL CO., Milwaukee, Wis., announces that its new administration building which is now in the process of construction will be completed before the

first of the year. It is 40 ft. wide by 120 ft. long by 40 ft. high and the basement has been especially designed to accommodate a show room for the company's products. The new building will be occupied by the executive, sales, advertising, accounting, purchasing, and engineering departments of the company.

CHICAGO BRIDGE & IRON WORKS, Chicago, announces the opening of a Cleveland sales office, to be under the direction of George S. Sangdahl. Mr. Sangdahl comes to Cleveland from a similar position in Montreal with the Horton Steel Works, Ltd., a subsidiary of the Chicago Bridge & Iron Works. Associated with Mr. Sangdahl will be A. W. Warren, at the present time in the Chicago office of the company. The Cleveland office will handle a territory consisting of Ohio, West Virginia, and parts of Kentucky, New York, Pennsylvania and Maryland.

SMITH ENGINEERING WORKS, Milwaukee, Wis., are moving into a new plant where all of their manufacturing operations will be conducted under one roof. The new building is 245x195 ft. in plan and is situated on 6 acres of ground that the company has purchased in a developing manufacturing district at Richards St. and Lake Blvd. The company's old plant has been sold to the T. L. Smith Co. and will be occupied by that company as soon as present moving operations are completed.

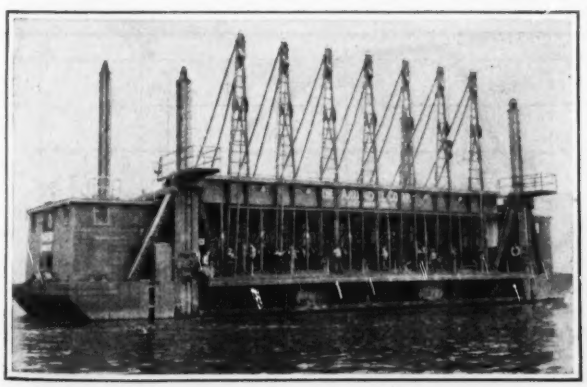
Equipment and Materials

Specially Built Drilling Outfit Deepening East River, N. Y. City

In order to provide an exit and entrance to New York harbor through Long Island Sound suitable for use by battleships and ocean liners, the channel of the East River is being deepened under the direction of the Corps of Engineers, U. S. Army. The work has been under way for some time and as planned will take from five to ten years longer.

One of the drilling plants being used on this work is of special design and is utilizing big blast hole drilling methods. The drilling plant is placed on an all-steel barge, 111x48 ft. in plan and 12 ft. deep, electrically operated from two Diesel engine generator sets. The drilling apparatus on the barge consists of seven No. 14 big blast hole drills manufactured by the Sanderson-Cyclone Drill Co., Orrville, Ohio. Each drill is operated by a separate 15-hp. d.c. motor and drills holes 6¾ in. in diameter. The drills are spaced on 10-ft. centers on the barge. A perforated casing is being used so that the action of the tides washes the drill cuttings away. After a set of seven holes is drilled, they are immediately loaded, the casing pulled and the charge fired.

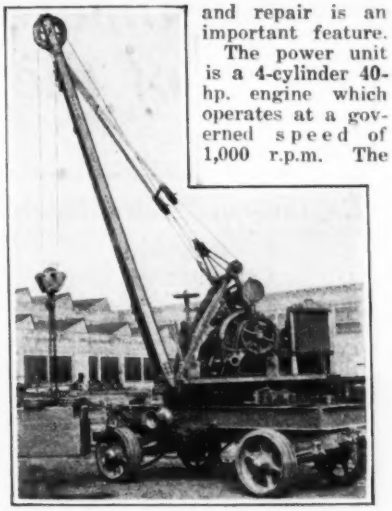
At the point where operations are now being carried on (¼ mile above Hell Gate bridge), the water is 20 ft. deep and the holes penetrate the rock bottom from 20 to 30 ft. A set of seven holes is drilled in from 6 to 8 hr. The holes are loaded with 500 to 1,100 lb. of dynamite, depending on the depth of the hole. Dynamite of 90 per cent gelatin is being used. About one-third of the way up from the bottom of the main charge, which is 6 in. in diameter, the cap is inserted in a stick of 60 per cent dynamite about 1 ft. long and 2 in. in diameter. This fires much more readily than 90 per cent dynamite and detonates the major loading. Dredges will follow the blasting operations, carrying the spoil material out to sea.



Truck and Trailer Crane Is Compact Unit

The new crane, Model 203-A, of the Harnischfeger Corporation, Milwaukee, Wis., is designed for mounting on either a truck or trailer. The illustration shows it mounted on trailer running gears. This trailer crane is provided with mechanism to propel itself at a speed of 1¼ m.p.h. on the job. On both truck and trailer cranes, jacks, screwing down against the rear wheels, relieve the springs of all load when the crane is operating.

Features of the crane are said to be speed, compactness, light weight, sturdiness and accessibility. Its mounting, of course, facilitates its movement between jobs and while working it has a line speed of 125 f.p.m. Compactness is achieved mainly by having all three drums mounted on one shaft. This arrangement places all main machinery behind the center pin thus facilitating balance and cutting down the amount of counterweighting. The machine can work in close quarters since its width is 8 ft. 4 in. and tail swing 7 ft. 1½ in. The weight of crane, exclusive of mounting, is 13,000 lb. Cast steel is used for the revolving and drum-bearing frames. Accessibility for maintenance and repair is an important feature.



The power unit is a 4-cylinder 40-hp. engine which operates at a governed speed of 1,000 r.p.m. The machine is built to handle a ½ yd. clamshell bucket on a 25-ft. boom or to lift 10,000 lb. at a 10-ft. radius. Both hoisting and digging drums run at the same speed making it possible to use the clamshell without special attachments. The boom hoist can be operated at the same time or independently from the main drums and swinging machinery.

Publications from the Construction Industry

Concrete — RANSOME CONCRETE MACHINERY CO., Dunellen, N. J., has reissued a very useful booklet entitled "How to Make and How to Use Concrete." It was written and compiled in 1917 by H. Colin Campbell, of the Portland Cement Association, and has been revised and reprinted in 1925. The price of the booklet is $1. It is essentially a treatise and its title is probably its best description. A number of useful tables concerning such things as quantities of materials in various concrete mixes, capacities of tanks, weights and areas of reinforcing steel, and like material are included in the rear of the booklet.

Concrete Reinforcing — CONCRETE STEEL CO., New York City, in a new 40-p. catalog, describes its various products manufactured for use in all types of reinforced-concrete construction. Sections of the booklet are devoted to Havemeyer bars, collapsible spirals, expanded metal, spacing and holding devices, besides many special reinforcing units. Each piece of equipment is both illustrated and described.

Trailers — FRUEHAUF TRAILER CO., Detroit, Mich., describes its complete line of motor truck trailers in a new 23-p. booklet. Specifications and descriptions are given of each model and photos and text describe the outstanding construction features. Several pages of illustrations are given showing the applications of the trailers in various industries.

Engineering News-Record Statistics of the Construction Industry

November 5, 1925 — *in the United States* — Vol. 95, No. 19

Engineering News-Record CONSTRUCTION COST Index Number (1913 = 100)

MONTHLY
January, 1924, to Date

November, 1925	205.95
October, 1925	205.35
November, 1924	205.70
Peak, June, 1920	273.80
1913	100.00

1924

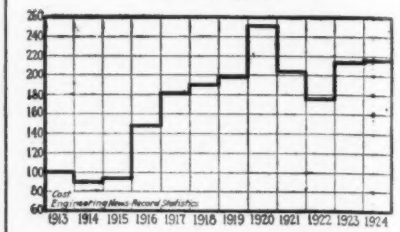
Jan.	217.90	May	222.38	Sept.	211.25
Feb.	220.30	June	216.85	Oct.	207.55
March	224.60	July	214.40	Nov.	205.70
April	221.60	August	213.15	Dec.	208.58

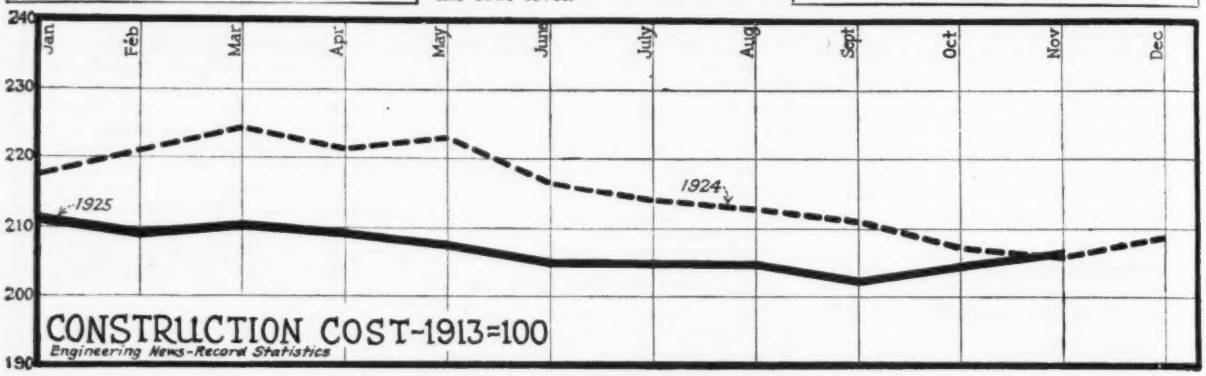
1925

Jan.	210.40	May	207.20
Feb.	209.70	June	204.60
March	210.20	July	204.60
April	209.55	August	204.60
	Sept.	202.10	

ENGINEERING NEWS-RECORD'S Construction Cost Index Number is 0.6 points above the October level, owing to higher cost of structural timbers, offsetting a decline in the price of cement. The average rate for common laborers is still 54c. per hr. for the entire country as against 53c. two months ago and 56c. one year ago. Thus general construction cost is 0.1 per cent higher than a year ago and 33 per cent under the peak; it is 105 per cent above the 1913 level.

YEARLY
1913 to 1924





Engineering News-Record CONSTRUCTION VOLUME Index Number (1913 = 100)

MONTHLY
January, 1924, to October, 1925

October, 1925	233
September, 1925	262
October, 1924	164
Peak, August, 1925	266
1913	100

1924

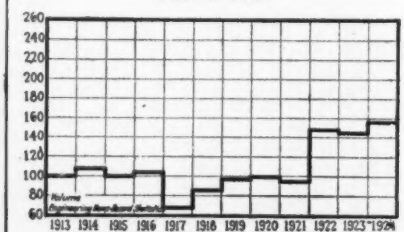
January	125	May	194	September	159
February	144	June	149	October	164
March	161	July	161	November	128
April	159	August	162	December	145

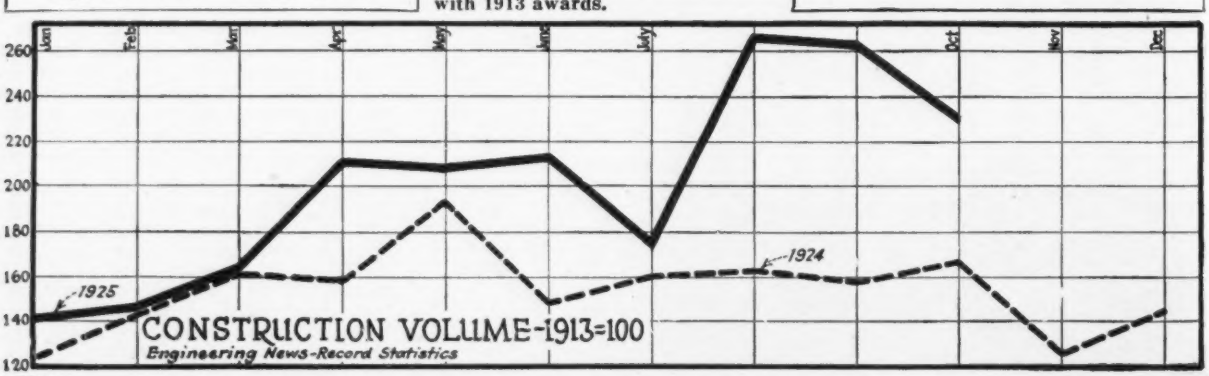
1925

January	141	May	209
February	145	June	214
March	161	July	178
April	211	August	266

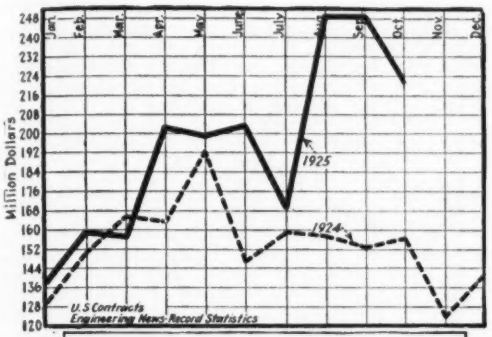
ENGINEERING NEWS-RECORD'S Construction Volume Index Number is 233 for the month of October, and 154 for the whole of 1924, as against 100 for 1913. This means that the actual volume of construction in 1924 (not the mere money-value of the contracts let that year) is 54 per cent above the volume of construction for 1913. The monthly volume number, 233 for October, 1925, contains the increment of construction and indicates the rate at which contracts are being let as compared with 1913 awards.

YEARLY
1913 to 1924

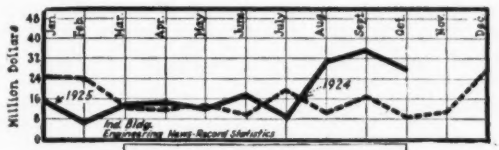




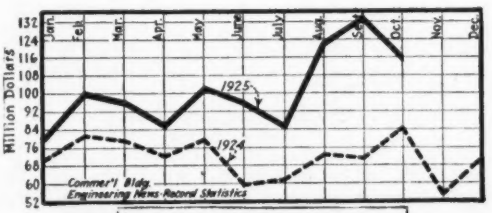
Monthly Statistics of the Construction Industry



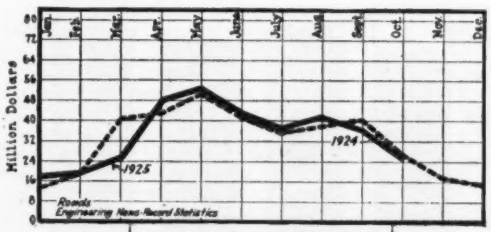
Contracts Awarded in the United States
Reported in E. N. R.



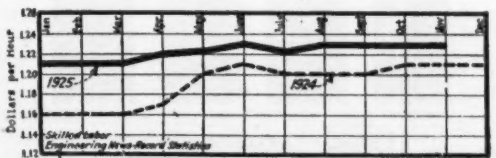
Industrial Building Awards
$40,000 and Over



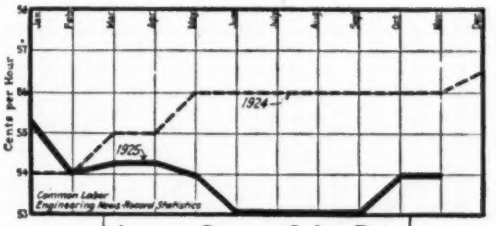
Commercial Building Awards
$150,000 and Over



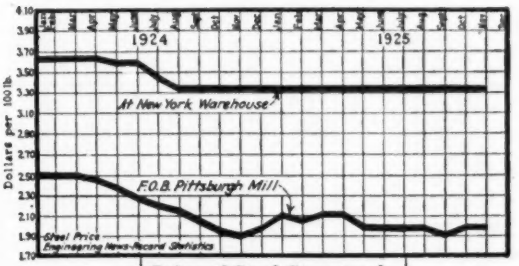
Street and Road Lettings
$25,000 and Over



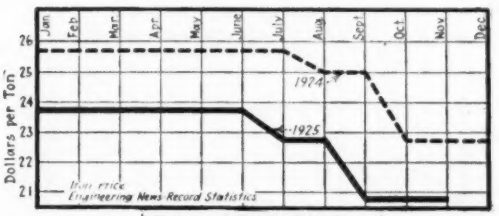
Average Wage of Skilled Building Trades
Bricklayers, Carpenters and Steel Erectors



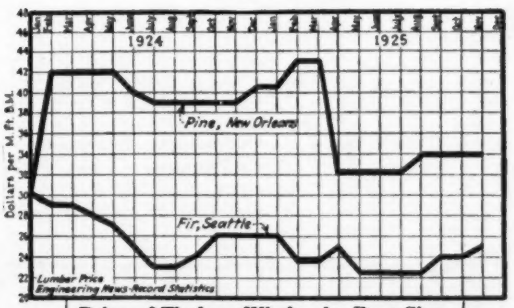
Average Common Labor Rate
Pick and Shovel Men



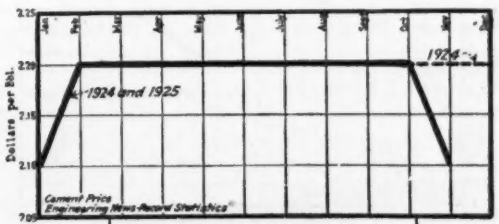
Price of Steel Structurals
Shapes 3-In.; Plates ¼-In.



Price of Basic Pig Iron
F.o.b. Pittsburgh

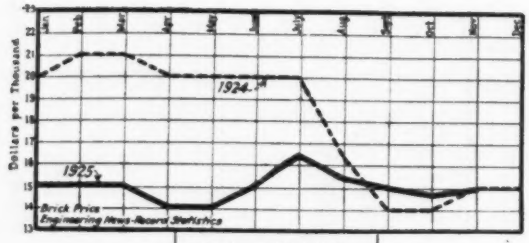


Price of Timbers, Wholesale, Base Sizes
Car Lots to Contractors

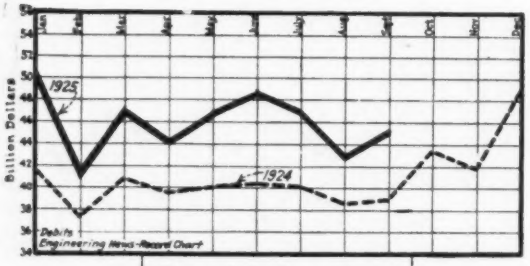


Net Price of Portland Cement
Car Lots, F.o.b. Chicago

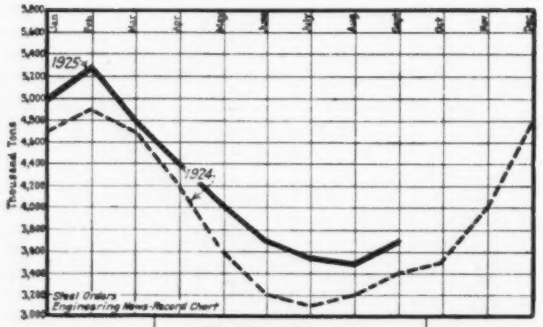
Monthly Statistics of the Construction Industry



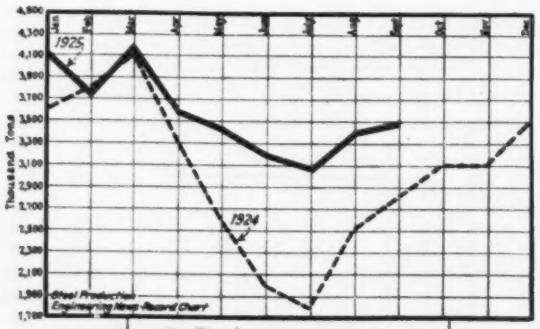
Price of Brick
At Dock, New York



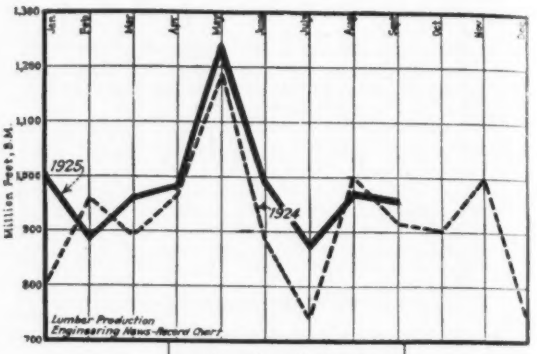
General Business Trend
Bank Debits—Federal Reserve



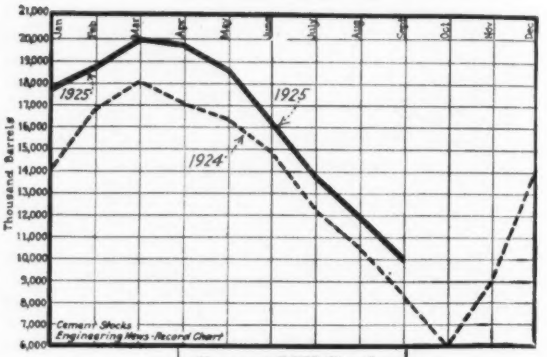
Unfilled Tonnage
On Books of U. S. Steel Corp.



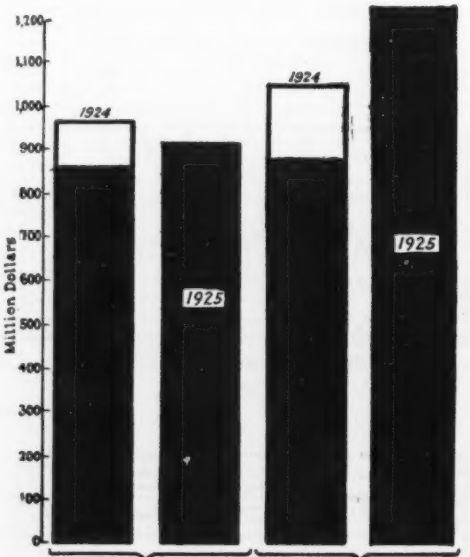
Steel Ingot Output
Gross Tons; Am. Iron and Steel Inst.



Lumber Output
Nat. Lumber Mfrs. Assn.



Cement Mill Stocks
Geological Survey



Public—Contracts—Private
Jan. 1 to date ▬
Reported by E. N.-R.

October Contracts Reach Record Total for That Month—This Year to Date 23 Per Cent Ahead of Last

THE third consecutive record month, in money value of contracts let, has just closed. October construction was 42 per cent ahead of the same period last year, and the heaviest for that month on record.

Total contracts awarded from Jan. 1 to Nov. 1, 1925, were 23 per cent greater than for the corresponding period in 1924.

Taking a minimum of $15,000 on water-works and excavations; $25,000 on other public works; $40,000 on industrial, and $150,000 on commercial buildings, the following figures show the month of October during the past thirteen years:

1913.....	$50,043,000*	1920....	$93,969,000
1914.....	54,750,000*	1921....	99,914,000
1915.....	47,546,000	1922....	134,759,000
1916.....	56,007,000	1923....	157,746,000
1917.....	67,050,000	1924....	196,387,000*
1918.....	75,329,000*	1925....	278,017,000*
1919.....	248,717,000*	* Five issues of E. N.-R.	

In money value, water-works contracts were five times greater than in October, 1924; industrial buildings tripled; excavating work gained 98 per cent; sewers, 53 per cent; commercial buildings, 37 per cent; and bridges, 11 per cent. A drop of 8 per cent was shown in street and road lettings and 14 per cent in Federal Government projects. Unclassified jobs were just about as heavy as in 1924.

Comparing October with the month preceding, there was preceptible slowing down in twenty of the forty-eight states. These included all of the New England states except New Hampshire and Rhode Island; the Middle Atlantic section except New York and New Jersey; West Virginia; the Carolinas; Georgia; Kentucky; the Dakotas; Nebraska; Oklahoma; Texas; New Mexico; Arizona; and Nevada.

The eight outstanding jobs of the month were: A section of New York subway, $7,666,222; telephone exchange, Cleveland, O., $7,500,000; section of Welland canal, Ontario, $7,000,000; reclamation project, Belmont, Calif., $5,000,000; power house, Baltimore, Md., $4,000,000; Ford plant, Somerville, Mass., $4,000,000; railroad extension, N. P. R.R., $3,500,000; excavating work on Lake front, Chicago, Ill., $3,000,000.

Business Briefs

Call money: 5 per cent, Nov. 2.

Time loans: short terms, 4⅜@5 per cent; longer periods, 5 per cent.

FOREIGN EXCHANGE (DEMAND)

	Par	This Week	Last Week	Year Ago
Sterling	$4.86⅝	$4.84⅝	$4.84⅝	$4.53⅞
France	.193	.0418⅛	.0427	.0523⅜
Lira	.193	.0396⅛	.0399¼	.0435⅛

Value of Contracts Let in the United States and Canada, October, 1925

	New England	Middle Atlantic	Southern	Middle West	West of Mississippi	Far West	United States	U. S. Jan. 1 to Nov. 1	Canada
Waterworks	$36,000	$450,000	$65,000	$3,958,000	$846,000	$12,245,000	$17,600,000	$64,354,000	$175,000
Sewers	85,000	2,793,000	121,000	4,369,000	1,484,000	441,000	9,293,000	72,181,000	273,000
Bridges	168,000	2,063,000	775,000	471,000	1,247,000	478,000	5,202,000	55,653	30,000
Excavation, dredging, etc.	21,000	45,000	432,000	3,049,000	439,000	5,000,000	8,986,000	33,592,000	7,113,000
Streets and roads	1,989,000	4,598,000	4,845,000	5,255,000	10,001,000	4,728,000	31,416,000	378,927,000	756,000
Industrial building	5,410,000	15,680,000	1,597,000	6,695,000	2,487,000	2,729,000	34,598,000	200,208,000	3,500,000
Commercial building	14,844,000	59,451,000	10,448,000	37,944,000	11,173,000	11,083,000	144,943,000	1,108,691,000	880,000
Federal government	162,000	1,991,000	463,000	15,000	626,000	20,000	3,277,000	29,800,000	
Unclassified	83,000	18,257,000	1,150,000	263,000	2,079,000	870,000	22,702,000	190,307,000	280,000
Oct., 1925	$22,798,000	$105,328,000	$19,896,000	$62,019,000	$30,382,000	$37,594,000	$278,017,000	$2,133,713,000	$13,007,000
Oct., 1924	12,914,000	74,918,000	14,684,000	32,764,000	32,510,000	28,597,000	196,387,000	.....	10,000,000
1925, Jan. 1 to Nov. 1	176,010,000	770,127,000	203,347,000	386,240,000	360,434,000	237,555,000	2,133,713,000	.....	175,573,000
1924, Jan. 1 to Nov. 1	125,094,000	526,870,000	189,781,000	369,421,000	290,378,000	232,556,000	1,734,100,000	.....	83,183,000

Labor Rates and Conditions Throughout the Country

THE present high rate of activity enjoyed by the construction industry may be traced directly to the low rate of interest charged on borrowed money.

Any building shortage incurred by the war having long since been made up, the duration of the present building boom is governed completely by the length of time that cheap money will remain as plentiful as it is now.

Total loans and investments are 10 per cent heavier than at the peak of the 1920 period of inflation. If it were not for the fact that money rates show little tendency toward radical change in the very near future, the end of this era of high construction volume could be predicted.

The increasing volume of autumn trade is everywhere evident; favorable factors greatly outweighing the negative influences.

Among the principal signs of improvement are: Proposed construction sufficient to assure a November contract volume equal to that of October; gain in bank debits; increasing employment of labor; fewer business failures; favorable trade balance with other countries; moderate reserve stocks of materials, higher prices for stocks and bonds; accelerated demand for steel, non-ferrous metals, clothing, dry goods, and shoes; heavier freight loadings (compared with a year ago) of merchandise in less-than-carlot quantities, a condition reflecting the prosperity of the small shipper.

Principal among the adverse conditions are: the anthracite coal strike; grain prices slightly below commodity prices; downward tendency of grain, livestock, and wool prices despite uptrend in other wholesale commodities; decline in excess reserves of Federal Reserve system; seasonal restriction of automotive output; emigration of laborers in excess of immigration.

Local conditions in several of the most important industrial centers follow:

Atlanta—Large building program under way and in prospect. No shortage of labor.

Baltimore—Construction particularly active. Plasterers reported scarce.

Birmingham — Building conditions continue good, with a few large and many small structures being erected. General labor conditions favorable.

Boston—Building trades employers voted to notify ironworkers' union that rate of $1.25 per hr. demanded by latter, will be refused and that if workers do not agree to present basis of $1.10 per hr., non-union men will be called in to fill vacancies.

Cincinnati—Surplus of painters and common laborers. Building continues active.

Chicago—Laborers plentiful. Foundation work being rushed owing to unseasonable weather.

Cleveland — Skilled mechanics reported scarce; surplus of common laborers. Construction continues active.

Dallas—Carpenters preparing to present demands for increase of $1 per day over present rate, change not to become effective until Jan. 1, 1926.

Denver—Construction is active with no shortage of building laborers, skilled or unskilled.

Detroit—Acute shortage of common building laborers reported. Local factories recently added about 8,000 men to pay-rolls, affording indoor work to the laborers during cold weather.

Kansas City, Mo.—Construction particularly active. Practically all building trades mechanics employed.

Los Angeles—Extensive construction program under way. No scarcity of men in the building trades.

Minneapolis—Many public improvement projects under way. No unemployment in the building trades. In many cases open-shop building trades mechanics are being paid union rates.

Montreal—Ample supply of building trades mechanics.

New Orleans—Active building program under way. Practically all building trades mechanics employed.

New York—Present volume of construction sufficient to absorb practically all building trades mechanics and unskilled laborers. Nearly all other industries active. Average weekly earnings, all industries combined, are

Current Building Trades Wage Rates Per Hour

(Higher rates indicated by +, decreases by —)

Cities	Bricklayers	Carpenters	Hoisting Engineers	Hod Carriers	Pile Drivers	Structural Iron Workers	Common Labor
Atlanta	$1.12½	$0.70	$0.70	$0.50	.....	$0.75	$0.25@.30
Baltimore	1.50@1.75	1.00@1.20	1.00@1.12½	1.00	$0.65	1.12½	.40
Birmingham	1.00@1.50	.35@.87½	.75@1.25	.50@.75	.....	.75@1.75	.20@.40
Boston	1.25	1.10	1.10@1.30	.70@.75	1.10	1.10	.50@.75
Cincinnati	1.50	1.25	1.25	.92½	1.25	1.25	40@55
Chicago	1.50	1.37½	1.37½	.87½	1.37½	1.37½	.82½@.87½
Cleveland	1.50	1.25	1.30	.87½	1.00	1.50	.87½
Dallas	1.62½	1.00	1.00	.40@.75	.87½	1.00	.30@.50
Denver	1.62½	1.12½	1.12½@1.18¾	.81¼@.87½	1.00	1.15⅝	.35@.55
Detroit	1.50	.70@1.00	.85@1.00	.90	.85@1.00	1.12½	.50@.60
Kansas City	1.37½	1.25	1.12½@1.25	.90	1.12½	1.12½	+.40@.75
Los Angeles	1.25	.93¾	1.00	....	.81¼	1.00	.50
Minneapolis	1.12½@1.25	.87½@90	.87½	.71½	.....	.87½	—.45@.55
Montreal	1.00	.65	.62½	.30@.35	.50	.80	—.20@.35
New Orleans	1.25	.90	1.00	.65	.85	1.25	.35@.40
New York	1.50	1.31¼	1.50	1.00	1.00@1.12½	1.50	.55@.75
Philadelphia	1.50	1.12½	1.02¼	1.12½	1.00	1.12½@1.25	.45@.50
Pittsburgh	1.62½	1.37½	1.37½@1.43¾	1.09⅜	.....	1.43¾	.75
St. Louis	1.75	1.50	1.50@1.65	1.15@1.25	1.50	1.50	+.45@1.00
San Francisco	1.25	1.00	1.00	.81¼	1.00	1.12½	.50@.55
Seattle	1.37½	1.12½	1.00@1.12½	1.00	1.00@1.12½	1.12½	.50@.62½

slightly higher than a year ago.

Philadelphia—Scarcity of tile setters, terrazzo workers, slate roofers, sheet-metal workers, common laborers, and marble workers. Unemployment reported among carpenters, cement finishers and painters. Plenty of plasterers and bricklayers.

Pittsburgh—Nearly all industries are active in this district, construction especially so. Building trades mechanics plentiful and well employed.

St. Louis—The first nine months of 1925 shows that this year will be the heaviest building year on record for St. Louis. Money value of contracts let is already more than double that for the entire year 1919.

San Francisco—Construction active in this city and in Oakland and vicinity. Building trades mechanics very busy.

Seattle—Employment in the building trades continues active. Logging camps also operating at increased rate.

Monthly Prices of Construction Materials

Ups and Downs of the Market

VOLUME of construction continues heavy although cost is but a fraction of a per cent above a year ago. Firmness with advancing tendency is noted in pig iron, railroad ties, spikes, nails, cone-head rivets, iron and steel scrap, steel sheets, rope, and lumber. The principal declines of the month occurred in portland cement and linseed oil. There is slight fluctuation in prices of aggregates in some of the Western cities. The usual price stability is shown by steel pipe, standard rails, flagging, curbing, window glass, piling, red and white lead.

Building materials seriously affected by general inbound freight embargo which became effective throughout Florida a week ago today.

Pig Iron—Higher coke prices, due to abnormal domestic demand, forcing pig iron up. No. 2 foundry iron, particularly, advancing at the rate of about 50c. per ton per week. Maximum quotations, however, apply to first quarter deliveries.

Railway Supplies—Present purchasing of rails and other equipment is in fairly large volume, with prices firm. Light rails are about $1 per ton below a year ago. Mill price of standard spikes is firmer than a month ago. Oak and sap pine-cypress ties are higher in the St. Louis district.

Pipe—Prices of iron and steel pipe remain firm and unchanged, with particularly good export demand for the latter. Sewer pipe prices showed no change in seventeen out of twenty cities reporting regularly to *Engineering News-Record*.

Road and Paving Materials—The following is representative of the situation in road oils: Prices at New York unchanged; slight advance in St. Louis district; declines in Dallas and San Francisco. Aside from a drop of $1.50 per ton in asphalt at San Francisco, no other changes occurred in twenty cities reporting to *Engineering News-Record*. Granite blocks up 15c. and wood blocks, 10c. per sq.yd. in Kansas City.

Sand, Gravel and Crushed Stone—Change in freight rates resulted in a reduction of 7½c. per cu.yd. in sand and gravel at Chicago. Sand down 10c. in St. Louis and 12c. per cu.yd. in Detroit. Crushed stone advanced 10c. per ton in St. Louis and Detroit.

Lime and Cement—Lime rose sharply in Detroit and Dallas and declined in Kansas City during the month. Cement dropped 10c. per bbl. in Pittsburgh, Minneapolis, St. Paul, Duluth, Cleveland, Cincinnati, Chicago and four other Mid-Western cities; 20c. per bbl. in Toledo and Detroit, following decline at mills.

Brick and Hollow Tile—Common brick is about 50c. per M. higher than a month ago in New York. Dallas reports a drop of 50c. and Kansas City, $1.50 per M. from the October level.

Structural Steel—Actual operation of the "Pittsburgh plus" system ceased slightly over thirteen months ago. At the present time all reports point to a good future in the steel industry. It is a notable fact, however, that steel prices in the West, where the greatest benefits from the abolition of "Pittsburgh plus" were expected to mature, are not conspicuously different from those in other parts of the country.

Lumber—Aside from some declines in pine and fir in Boston, Kansas City, Minneapolis and Seattle, most of the other seventeen cities reported slight advances in boards, timbers and dimension lumber. Unusually heavy demand for pine in Florida boom area affected by freight embargo.

Iron and Steel Scrap—Scarcity of certain grades of iron may result in higher scrap quotations. Advances predominate, comparing present prices with those of a month ago.

Miscellaneous—There is marked firmness in cone-head rivets, nails, steel sheets and rope. Linseed oil is tending downward throughout the country.

E. N.-R. Prices of Construction Materials

Price advances since last month are indicated by **heavy type**; declines by *italics*

PIG IRON—Per Gross Ton f.o.b.:

	Nov. 5	One Year Ago
CINCINNATI		
No. 2 Southern (silicon 2.25@2.75)	$23.05	$21.55
Northern Basic	22.27	21.27
Southern Ohio No. 2 (silicon 1.75@2.25)	22.77	21.77
NEW YORK, tidewater delivery		
Southern No. 2 (silicon 2.25@2.75)	27.37	25.10
BIRMINGHAM		
No. 2 Foundry (silicon 2.25@2.75)	**20@21**	18.00@18.50
PHILADELPHIA		
Eastern Pa., No. 2X (2.25@2.75 sil.)	22.26	22.34
Virginia No. 2 (silicon 2.25@2.75)	29.17	29.75
Basic	21.16	21.25
Gray Forge	.....	21.25
CHICAGO		
No. 2 Foundry Local (silicon 1.75@2.25)	22.00	20.50
No. 2 Foundry Southern (silicon 2.25@2.75)	25.55	24.50
PITTSBURGH, including freight charge ($1.76) from the Valley		
No. 2 Foundry Valley (silicon 1.75@2.25)	20.77	22.77
Basic	20.77	22.77
Besemer	20.77	23.77

SCRAP—The prices following are f.o.b. per ton paid by dealers:

	New York	Chicago	Birmingham
No. 1 railroad wrought	**$15.25**	**$15.00@$15.50**	$12.00@$13.00
Stove plate	*11.12½*	**15.00@15.50**	13.00@13.50
No. 1 machinery cast	18.25	17.00@17.50	16.00@16.50
Machine shop turnings	10.25	.....	7.00@8.00
Cast borings	**11.85**	11.50@12.00	7.00@8.00
Railroad malleable	**16.25**	16.00@16.50	17.00@18.00
Re-rolling rails	14.50	**17.00@17.50**	16.50@17.00
Re-laying rails	23.50	.....	21.00@22.00
Heavy melting steel	12.50	14.30@14.55	.....

Railway Supplies

STEEL RAILS—The following quotations are per ton f.o.b. for carload or larger lots. For less than carload lots 5c. per 100 lb. is charged extra:

	Pittsburgh				
	Nov. 5	One Year Ago	Birmingham	Chicago	St. Louis
Standard bessemer rails	$43.00	$43.00	$43.00	$43.00	$47@49
Standard openhearth rails	43.00	43.00	43.00	43.00	49@50
Light rails, 8 to 10 lb.	.....	33@35	34@36	1.80@1.90	.....
Light rails, 12 to 14 lb.	32@34	33@35	34@36	1.80@1.90	1.90@1.95*
Light rails, 25 to 45 lb.	32@34	36@39	34@36	1.80@1.90	1.85@1.90*
Re-rolled rails	27@30	27@32.50	.....	.....	18.50

*Per 100 lb.

RAILWAY TIES—For fair-sized orders, the following prices per tie hold:

	6 In. x 8 In. by 8 Ft.	7 In. x 9 In. by 8½ Ft.
Chicago, white oak, plain	$1.40	$1.75
Chicago, empty cell creosoted	1.75	2.10
Chicago, zinc treated	1.55	1.90
San Francisco, green Douglas fir	.84	1.14
San Francisco, empty cell creosoted, Douglas fir	1.70	2.25
St. Louis, white oak, plain	**1.10**	**1.30**
St. Louis, zinc treated	**1.50**	**1.70**
St. Louis, red oak, plain	**1.00**	**1.20**
St. Louis, sap pine-cypress	**.85**	**1.05**
Birmingham, white oak	1.25	1.45

TRACK SUPPLIES—The following prices are base per 100 lb. f.o.b. Pittsburgh mill for carload lots, together with the warehouse prices at the places named:

	Pittsburgh				San Francisco	Birmingham
	Nov. 5	One Year Ago	Chicago	St. Louis		
Standard spikes, ⅝-in. and larger	$2.80	$2.70@$2.80	$3.55	$3.65	$4.35	$2.90
Track bolts	3.90@4.15	3.75@4.00	4.55	3.25	5.85	3.90
Standard section angle bars	2.75	2.75	3.30	3.25@3.75	4.00	3.85

Pipe

WROUGHT PIPE—The following discounts are to jobbers for carload lots at Pittsburgh mill:

BUTT WELD

Inches	Steel Black	Steel Galv.	Inches	Iron Black	Iron Galv.
1 to 3	62	50½	1 to 1½	30	13

LAP WELD

2	55	43½	2	23	7
2½ to 6	59	47½	2½	26	11
7 and 8	56	43½	3 to 6	28	13
9 and 10	54	41½	7 to 12	26	11
10 and 12	53	40½			

BUTT WELD, EXTRA STRONG, PLAIN ENDS

1 to 1½	60	49½	1 to 1½	30	14
2 to 3	61	50½			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	53	42½	2	23	9
2½ to 4	57	46½	2½ to 4	29	15
4½ to 6	56	45½	4½ to 6	28	14
7 and 8	52	39½	7 and 8	21	7
9 and 10	45	32½	9 to 12	16	2
11 and 12	44	31½			

STEEL PIPE—From warehouses at the places named the following discounts hold for welded steel pipe:

	Black			
	New York	Chicago	Birmingham	St. Louis
1 to 3 in. butt welded	53%	54%	62%	49%
3½ to 6 in. lap welded	48%	51%	59%	46%

	Galvanized			
	New York	Chicago	Birmingham	St. Louis
1 to 3 in. butt welded	39%	41%	50½%	36%
3½ to 6 in. lap welded	35%	38%	47½%	33%

Malleable fittings, Classes B and C, banded, from New York stock sell at list plus 4% less 5%. Cast iron, standard sizes, 36—5% off.

CAST-IRON PIPE—The following are prices per net ton for carload lots:

	Birmingham	Burlington, N. J.	New York Nov. 5	New York One Year Ago
4 in.	$45.00	$52.00@$53.00	$54.60@55.60	$61.60@62.60
6 in. and over	41.00@42.00	48.00@49.00	50.60@51.60	56.60@57.60

	Pittsburgh	Chicago	St. Louis	San Francisco
4 in.	$53.20@54.20	$53.20@54.20	$52.00	*$57.00*
6 in. and over	49.20@50.20	49.20@50.20	48.00	*53.00*

Gas pipe and Class "A," $4 per ton extra.

CLAY DRAIN TILE—The following prices are per 1,000 lin.ft.:

Size, In.	New York Nov. 5	New York One Year Ago	St. Louis	Birmingham	San Francisco	Dallas
3	$48.00	$45.00	$40.00	$45.00	.....	$73.00
4	50.00	55.00	40.00	56.00	$76.50	110.00
5	70.00	80.00	.....	80.00	97.75	118.00
6	92.00	105.00	70.00	100.00	127.50	150.00
8	160.00	170.00	170.00	165.00	212.50	210.00

SEWER PIPE—The following prices are in cents per foot for standard pipe in car load lots, f.o.b., except as otherwise stated:

Size, In.	New York Delivered	Pittsburgh	Birmingham	St. Louis	Chicago	San Francisco	Dallas
3	.....	$0.081	$0.10	.....	$0.09	$0.12	.....
4	.....	.081	.10	$0.10	.09	.15	$0.15
5	.....	.1215	.135	.....	.13½	.18	.18
6	$0.21	.1215	.135	.14	.13½	.21	.21
8	.35	.189	.21	.225	.21	.30	.325
10	.52	.2835	.315	.315	.31½	.42	.476
12	.66	.3645	.45	.405†	.40½	.56	.612
15	1.14†	.486	.54	.675†	.54	.92	1.02
18	1.65†	.675	.75	.945†	.75	1.32	1.53
20	1.98†	.81	.90	1.26†	.90	.....	.....
22	2.65†	1.08	1.20	.....	1.20	.....	1.564
24	2.97†	1.215	1.35	1.62†	1.35	2.16	2.04
27	4.65†	2.405	2.665	2.45†	2.75	3.00	3.34
30	5.16†	2.664	2.952	3.00†	3.75	3.60	4.06
33	6.98†	3.60	3.96	3.55†	4.50	.....	4.99
36	8.00†	4.10	4.51	3.95†	5.00	.....	5.42

Size, In.	3	5	8	12	24	36
Boston	$0.13	**$0.20**	$0.30	$0.60	$2.00†	$5.50†
Minneapolis	.....	.....	.225	.405	1.35	4.75
Denver	.135*	.18*	.27	.47	1.70	.....
Seattle	.14	.....	.35	.72†	2.60†	.....
Los Angeles	.1625	.195	.275	.495	1.65	.....
New Orleans	.115*	.117*	.295	.4725	1.575	.....
Cincinnati	.105	.1575	.245	.4725	1.575	4.715
Atlanta	.10*	.15*	.24	.40	1.55	.....
Montreal	.68‡	.45†	.70	1.35	4.50†	.....
Detroit	.07	.1125	.175	.3375	1.935†	5.6375†
Baltimore	*.11*	*.16½*	.259	.499	1.665	4.92
Kansas City, Mo.	**.13½***	*.15*	*.21*	.52	.....	.....
Philadelphia	.12	.18	.28	.54	1.80	4.66

*4-in., 6-in., 9-in., respectively. †Double Strength. ‡3-in. special.

Road and Paving Materials

ROAD OILS—Following are prices per gallon in tank cars, 8,000 gal. minimum f.o.b. place named:

		Nov. 5	One Year Ago
New York, 45% asphalt	(at terminal)	$0.065 @ $0.07	$0.055
New York, 65% asphalt	(at terminal)	.0675@.0725	.06
New York, binder	(at terminal)	.07 @ .075	.065
New York, flux	(at terminal)	.07 @ .075	.04
New York, liquid asphalt	(at terminal)	.07 @ .075	.06
St. Louis, 40@50% asphalt		**.05½**	.0475
St. Louis, 50@60% asphalt		**.05½**	.0481
Birmingham, 55% asphalt		.0475	.....
Dallas, 45% asphalt		*.0495*	.0495
Dallas, 55% asphalt		*.0655*	.0455
Dallas, binder		*.061*	.061
San Francisco, binder, per ton		*12.00**	11.00*

* F.o.b. Oleum, Cal. Freight to San Francisco, 80c. per ton.

E. N.-R. Prices of Construction Materials

ASPHALT—Price per ton in packages (350-lb. bbls. or 425-lb. drums) and in bulk in carload lots, f.o.b. points listed:

	Package	Bulk
New York (*Mexican*)	$23.00*	$18.50
Boston (*Mexican*)	22.50	18.50
Chicago (*Texas*)	27.00	23.00
San Francisco, *f.o.b. refinery*, Oleum, Cal.	18.00	13.00
Dallas (*Texas*)	27.10	21.10
Seattle, "*D*" *grade, California, f.o.b. Richmond*	19.50	13.50
Denver (*California*)	24.00	.....
Minneapolis, *f.o.b. Twin Cities (Stanolind)*	27.60	21.60
St. Louis (*Mexican*)	25.00	21.00
Baltimore (*Mexican*) (*f. o. b. refinery*)	22.50	18.50
Montreal (*Imperial*)	28.00	21.00
Atlanta (*Mexican*)	26.10	21.90
Detroit (*Mexican*)	27.00	23.00
Cincinnati (*Kentucky Rock*)	.....	11.65
Maurer, N. J. (*Bermudez*)	28.00	26.00
Maurer, N. J. (*Mexican*)	22.00	19.00
Philadelphia (*Mexican*)	24.00	22.00
Kansas City, Mo. (*Texas*)	27.30	22.30
Los Angeles ("*D*" *grade, California*)	19.50†	13.50†
Birmingham (*Mexican*)	27.00	21.00
New Orleans (*Mexican*)	26.00	17.00

*In drums. †f.o.b. El Segundo Refinery.

NOTE—Barrels or drums are optional in most cities. About 6 bbls. to the ton, and from 4 to 5 drums; 200 to 300 gal. to the ton.

PAVING STONE—

New York (grade 1)	5-in. granite, 30 blocks per sq.yd.	$147.00 per M.
San Francisco	Basalt block 4x7x8	70.00 per M.
Chicago	about 5x8x5 dressed	3.60 per sq.yd.
	about 5x8x5 common	3.25 per sq.yd.
Boston	5-in. Granite	135.00 per M.
Atlanta	Granite	2.50 per sq.yd.
Detroit	5-in. Granite	3.00 per sq.yd.
Baltimore	Granite	2.85 per sq.yd.
Montreal	Granite	104.75 per M.
New Orleans	Granite, 4x8x4	3.18 per sq.yd.
Cincinnati	Granite	135.00 per M.
St. Louis	Granite, 4x8x4	1.65 per sq.yd.
Kansas City	Granite	4.00 per sq.yd.
Philadelphia	Granite	3.90@4.25 per sq.yd.
Minneapolis	Sandstone	2.74 per sq.yd.

FLAGGING—

New York	Bronx, 4 ft. wide	$0.24 per sq.ft.
	Manhattan, 4 ft. wide	.24 per sq ft.
	Queens, 5 ft. wide	.26 per sq.ft.
	6x24-in. cross-walk	1.30 per lin.ft.

CURBING—*New York:* Bluestone per lin.ft., f.o.b. barge New York, 5x16 in., 88c.; *St. Louis:* Class "A" straight, delivered, 5x18 in., $1.05 per lin.ft.; roundings, $1.60. *Birmingham:* Limestone, 5x18-in., $1.05 per lin. ft.

WOOD BLOCK PAVING—	Size of Block	Treatment	Per Sq.Yd
New York	3	16	$2.40
New York	3½	16	2.70
Boston	3½	18	2.50
Chicago	4	16	2.25
Chicago	3½	16	2.10
St. Louis	3½	16	2.40
St. Louis	4	16	2.70
Seattle	4	16	Off market
Minneapolis	3½	16	2.49
Atlanta	3½	16	2.00
New Orleans	3	16	2.20
New Orleans	3½	16	2.30
New Orleans	4	16	2.40
Dallas	4	18	3.90
Baltimore	3½	16	None used
Montreal	4	16	4.50
Detroit	3	16	1.94
Detroit	4	16	.....
Cincinnati	3½	16	2.35
Kansas City	4	16	3.85
Philadelphia	4	16	None used

Construction Materials

SAND AND GRAVEL—Price, f.o.b. for cargo or carload lots to contractor is as follows, f.o.b., per cu.yd.:

	Gravel 1½ In. Nov. 5	Gravel 1½ In. One Year Ago	Gravel ¾ In. Nov. 5	Gravel ¾ In. One Year Ago	Sand Nov. 5	Sand One Year Ago
New York (*alongside dock*)	$1.75	$2.00	$1.75	$2.00	$1.00	$1.00
Denver	1.90	1.90	1.90	1.90	1.00	1.00
Chicago	*1.50*	..	*1.50*	..	*1.40*	....
St. Louis	1.45	1.45†	1.45	1.65†	*1.08*	1.18†
Seattle	1.50	1.50	1.50	1.50	1.50	1.50
Dallas	2.38	2.38	2.38	2.38	2.00	2.00
Minneapolis	1.65*	1.65*	1.65*	1.65*	1.25	1.25
Cincinnati	1.40†	1.40†	1.40†	1.40†	1.35†	1.35†
San Francisco	2.15	2.15	2.15	2.15	1.50	1.50
Boston	1.50†	1.50†	1.50†	1.50†	1.00†	1.00†
New Orleans	2.60	3.00	2.60	3.00	1.75	1.25
Los Angeles	0.85*†	1.50†	0.85*†	1.55†	0.50*†	1.10†
Atlanta	2.20†	1.90†	2.20	1.90†	1.65†	1.40†
Detroit	*2.00*	2.02	*2.00*	2.02	*1.50*	1.62
Baltimore	1.40	1.40	1.60	1.60	0.70*†0.70*†	
Montreal	1.25†	1.25†	1.25†	1.25†	1.25†	1.25†
Birmingham	2.00	2.00	2.00	2.00	1.50	1.30†
Philadelphia	2.10	2.10	2.10	2.10	1.50	1.50
Kansas City (Joplin chats)	4.00	4.00	4.00	4.00	0.66*†0.66*†	

New York—Grits, $1.75 per cu. yd.; ready mixed, $1.90.
Los Angeles—Freight from quarry, 70c. per ton, and is included in above price.
*At pit. † Per ton.

CRUSHED STONE—Price for cargo or carload lots, f.o.b. city, is as follows per cu.yd.:

	1½ In. Nov. 5	1½ In. One Year Ago	¾ In. Nov. 5	¾ In. One Year Ago
New York	$1.75	$1.75	$1.85	$1.85
Chicago	1.72½	....	1.87½	....
St. Louis	1.93*	1.75*	1.93*	1.75*
Dallas	2.40	2.40	2.63	2.83
San Francisco	2.15	2.15	2.15	2.15
Boston	1.60*	1.60*	1.60*	1.60*
Minneapolis	1.75	1.75	1.75	1.75
Kansas City	1.50	1.50	1.50	1.50
Denver	2.50	3.50	2.50	3.50
Seattle	3.00	3.00	3.00	3.00
Atlanta	2.20*	2.00*	2.20*	2.00*
Cincinnati	1.90*	1.90*	1.90*	1.90*
Los Angeles	1.00*	1.65	1.00*	1.75
Detroit	2.00*	1.70	2.00*	1.70
Baltimore	2.50	2.50	2.55	2.55
Montreal	1.80*	2.25*	1.90*	2.25*
Philadelphia	2.10	2.10	2.10	2.10
Pittsburgh	2.85	2.85	2.85	2.85
Cleveland	3.25*	3.25*	3.25*	3.25*
Birmingham	2.00	....	2.00	....

*Per ton.

CRUSHED SLAG—Price of crushed slag in carload lots, per net ton, at plan

	1½-In.	¾-In.	Roofing	Sand
Youngstown District	$1.25	$1.35	$2.00	$1.25
Steubenville District	1.25	1.30	2.00	1.30
Ironton District	1.40	1.40	2.00	1.40
Easton, Catasauqua, Pa.	....	....	2.50	....
Birmingham, Ala.	80@.90	1.15	2.05	....
Buffalo, N. Y., and Erie, Pa.	1.25	1.25	2.25	1.25
Cleveland, Ohio	1.30	1.30	1.30	1.30
Eastern Pa. and Northern N. J.	1.25	1.25	2.50	1.25
Western Pennsylvania	1.25	1.25	2.50	1.25
Longdale and Glen Wilton, Va.	1.25	1.25	2.50	
Toledo, Ohio	1.25	1.25	1.50	1.25

LIME—Warehouse prices:

	Hydrated, per Ton— Finishing	Hydrated, per Ton— Common	Lump, per Barrel— Finishing	Lump, per Barrel— Common
New York	$18.20	$12.00@$13.10	$3.50*	$2.25@2.75*
Chicago	20.00	18.00	.....	1.30†
St. Louis	23.00	19.00	14.00‡	14.00‡
Boston	19.50	*13.00@14.50*	3.75*	3.00*
Dallas	20.00	.....	.....	1.85†
Cincinnati	16.60	14.30	.....	13.40‡
San Francisco	22.00	.....	.....	1.60†
Minneapolis	25.50	21.00 (white)	1.60@1.70†	1.35†
Denver	24.00	.....	.....	2.70*
Detroit	16.00	16.00	.....	20.00‡
Seattle, *paper sacks*	24.00	.....	2.80†	.....
Los Angeles	25.00	18.00	3.50	19.50‡
Baltimore	24.25	17.85	2.55†	.....
Montreal	.....	21.00	.....	10.50‡
Atlanta	22.50	14.00	2.00†	1.30†
New Orleans	24.00	16.00	2.50†	2.00*
Philadelphia	23.00	.....	1.21†	.....
Kansas City	18.50	*15.00*	2.45*	2.10*
Birmingham	22.50	15.00	2.40†	1.85†

*Per 280-lb. bbl. (net). †Per 180-lb. bbl. (net). ‡Per ton.

NATURAL CEMENT—Price to dealers per bbl. for 500 bbl. or over, exclusive of bags:

	Nov. 5	One Year Ago
Minneapolis (Rosendale)	$2.80	$2.80
Kansas City (Ft. Scott)	*1.35*	1.50
Cincinnati (Utica)	1.72	1.72
Boston (Rosendale)	2.75	2.50
St. Louis (Carney)	2.50	2.35
Birmingham (Magnolia) pozzolan cement	2.40	2.10

PORTLAND CEMENT—Prices to contractors per bbl. in carload lots f.o.b points listed *without bags*. Cash discount not deducted.

	Nov. 5	One Month Ago	One Year Ago
New York, del. by truck	$2.50@2.60	$2.50@2.60	$2.50@2.60
New York, alongside dock to dealers	2.15	2.15	2.15
Jersey City	2.33	2.33	2.33
Boston	2.40	2.40	2.70
Chicago	*2.10*	2.20	2.20
Pittsburgh	*2.09*	2.19	2.19
Cleveland	*2.29*	2.39	2.39
Detroit	*2.15*	2.35	2.40
Indianapolis	*2.29*	2.39	2.41
Milwaukee	2.35	2.35	2.35
Duluth	*2.09*	2.19	2.19
Peoria	*2.27*	2.37	2.37
Cedar Rapids	*2.34*	2.44	2.44
Davenport	*2.29*	2.39	2.39
St. Louis	*2.20*	2.30	2.30
San Francisco	2.31	2.31	2.61
New Orleans	2.40	2.40	2.40
Minneapolis	*2.32*	2.42	2.42
Denver	2.84	2.84	2.84
Seattle	2.65	2.65	2.65
Dallas	2.05	2.05	2.05
Atlanta	2.25	2.25	2.35
Cincinnati	*2.37*	2.47	2.47
Los Angeles	2.52	2.52	2.60
Baltimore	2.50	2.50	2.50
Birmingham	2.40	2.40	2.40
Kansas City, Mo.	2.30	2.30	2.42
Montreal	1.80	1.80	1.80
Philadelphia	2.41	2.41	2.41
St. Paul	*2.32*	2.42	2.42
Toledo	*2.20*	2.40	2.45

NOTE—Bags 10c. each, 40c. per bbl.; 20c. each in Canada, 80c. per bbl.

Current mill-prices per barrel in carload lots, without bags, to contractors:

Buffington, Ind.	$1.85	Hudson, N. Y.	$2.05
Universal, Pa.	*1.85*	Leeds, Ala.	1.95
Steelton, Minn.	*1.90*	Hannibal, Mo.	2.05
Fordwick, Va.	2.05	Lehigh Valley District	1.95
Mitchell, Ind.	2.05	Wyandotte, Mich.	2.10
Iola, Kan.	1.95	Alpena, Mich.	1.95
Mason City, Ia.	2.00	Richard City, Tenn.	2.05
La Salle, Ill.	2.05	Kingsport, Tenn.	2.05

E. N.-R. Prices of Construction Materials

TRIANGLE MESH—Price per 100 sq.ft. in carload lots:

PLAIN 4-INCH BY 4-INCH MESH

Style Number	Weight in Pounds per 100 sq.ft.	Pittsburgh Mill	Chicago District Mill	Warehouse: New York	St. Louis	Dallas	San Francisco
032	22	$0.97	$1.01	$1.39	$1.06	$1.13	$1.22
049	28	1.23	1.29	1.76	1.35	1.38	1.55
068	35	1.51	1.58	2.16	1.66	1.67	1.91
093	45	1.94	2.03	2.77	2.13	2.00	2.46
126	57	2.39	2.51	3.45	2.63	2.55	3.03
153	68	2.86	2.99	4.11	3.14	3.15	.....
180	78	3.28	3.43	5.70	3.60	3.47	.....
245	103	4.33	4.53	6.21	4.75	4.58	.....
287	119	5.00	5.24	7.19	5.50	5.26	6.35
336	138	5.80	6.07	8.35	6.37	6.11	.....
395	160	6.72	7.04	9.65	7.38	7.12	.....
			PAVING				
036P	17	$0.74	$0.77	$1.06	$0.81	$0.76	.....
053P	24	1.04	1.09	1.50	1.14	1.07	.....
072P	31	1.32	1.38	1.90	1.45	1.39	.....
097P	40	1.70	1.78	2.45	1.87	1.90	.....
049R	24	1.04	1.09	.....	1.14	1.07	.....
067R	31	1.32	1.38	.....	1.45	1.39	.....
089R	40	1.70	1.78	.....	1.87	1.90	.....

In rolls, 48-, 52-, and 56-in. wide and in 150-, 200- and 300-ft. lengths. Galvanized is about 15% higher. Size of roll carried in New York warehouses, 48 in. wide x 150 ft. long, or 600 sq.ft.

EXPANDED METAL LATH—Prices in carload lots per 100 yd. for painted:

Weight in pounds	New York	Birmingham	Chicago	St. Louis	San Francisco	Dallas
2.2	$19.00	$22.00	$21.00	*$19.00*	$24.00	$23.50
2.5	**21.00**	23.00	23.00	*21.00*	26.00	25.00
3.0	**24.00**	26.00	27.00	*24.50*	30.00	28.50
3.4	**26.00**	28.00	29.00	*26.50*	33.00	31.00

BARS, CONCRETE REINFORCING—Current quotations per 100 lb.:

ROLLED FROM BILLETS

Inches	Pittsburgh Mill	Birmingham	Warehouse, Uncut: New York	Chicago	St. Louis	Dallas	San Francisco
½ and larger..	$2.00	$2.25	$3.24	$3.00	$3.15	$3.38	$3.35
⅝.....	2.10	2.35	3.34	3.10	3.25	3.43	3.45
¾.....	2.20	2.45	3.44	3.20	3.35	3.48	3.55
⅞.....	2.40	2.65	3.64	3.40	3.55	3.63	3.75
1.....	3.00	3.25	4.24	4.00	4.15	3.78	4.35

For standard classification of extras for size and cutting of steel bars, see bar card of July 15, 1923.

ROLLED FROM RAILS

	St. Louis	Dallas		St. Louis	Dallas
½ and larger.....	$2.55	$2.80	⅝.....	$2.95	$3.02
¾ in.....	2.65	2.85	¼.....	3.55	3.50
⅞.....	2.75	2.90	.....	.....	.....

BRICK—Contractors price per 1,000 in cargo or carload lots is as follows:

	Common: Nov. 5	One Month Ago	One Year Ago	Paving Block: 3-inch*	3½-inch*
New York (del.).....	$17.50@18.50	$17.50@18	$18.00	$45.00	$51.00
New York (at dock).	14.50@15.50	14.50@15	15.00	.....	.....
Chicago.....	12.00	12.00	.....	42.00	45.00
St. Louis, salmon (del.)	16.00	16.00	16@18	**40.00**	**42.50**
Denver, salmon.....	12.00	12.00	12.00	.....	.....
Dallas.....	*11.10*	11.60	12.10	35.00	.....
San Francisco.....	15.50	15.50	15.50	.....	.....
Los Angeles.....	11.50	11.50	15.00	(not used)	
Boston (del.).....	17.50	17.50	21.50	45.00	51.00
Minneapolis (del.).....	13.50	13.50	14.00	.....	.....
Kansas City.....	14.50	16.00	16.50	(no market)	
Seattle.....	15.00	15.00	15.00	.....	42.50
Cincinnati.....	17.00	17.00	17.00	40.00	45.00
Montreal.....	17.50	17.50	17.50	100.00†	68.00
Detroit (del.).....	16.00	16.00	17.50	37.50	40.50
Baltimore.....	18.00	18.00	18.00	40.00	45.00
Atlanta.....	10.50	10.50	10.50	40.00	.....
New Orleans.....	15.00	15.00	19.50	.....	.....
Birmingham.....	12.50	12.50	12.50	40.00	45.00
Philadelphia.....	*15@19.00*	15@19	19.00	40.00	50.00
Pittsburgh (del.).....	16.00	16.00	16.00	.....	.....
Cleveland.....	14.00	14.00	16.00	.....	.....

*For paving blocks 3x8½x4 and 3½x8½x4 respectively. †Imported.

HOLLOW TILE—Price per block in carload lots to contractor for hollow building tile.

	New York: Nos. 5 on Trucks*†	New York: One Year Ago	Chicago	Philadelphia	St. Louis	San Francisco†	Perth Amboy N. J., Factory*
4x12x12...	$0.1027	$0.1162	$0.075	$0.12	$0.07	$0.108	.....
6x12x12...	.1541	.1743	.096	.....	.095	.156	.....
8x12x12...	.1926	.2179	.135	.22	.132	.244	.....
10x12x12...	.....	.....	.167	.....	.165	.....	$0.252
12x12x12...	.....	.....	.215	.....	.195	.....	.312

*5 per cent off for cash. †Partition tile.

	4x12x12	8x12x12	12x12x12
Boston.....	*$0.085*	*$0.17*	.....
Minneapolis (f.o.b. cars).....	.0636	.106	$0.189
Minneapolis (delivered).....	.07	.116	.205
Cincinnati.....	.07485	.13745	.....
Kansas City.....	.085	.145	.....
Denver.....	.085	.155	.188
Seattle (delivered).....	.10	.20	.30
Los Angeles.....	.085	.172	.....
New Orleans.....	.13	.20	.....
Detroit (delivered).....	.1095	.2053	.2821
Montreal.....	.12	.225	.30
Baltimore.....	.125	.27	.....
Atlanta.....	.0893	.16749	.....
Dallas.....	.10	.19	.275
Birmingham.....	.11	.1824	.22
Pittsburgh (delivered).....	.068	.128	.179
Cleveland.....	.07	.149	.....

STRUCTURAL MATERIAL—Following are base prices f.o.b. mill, Pittsburgh and Birmingham, together with quotations per 100 lb. from warehouses at place named:

	Pittsburgh Mill	Birmingham	Warehouse: New York	Dallas	St. Louis	Chicago	San Francisco
Beams, 3 to 15 in....	$1.90@2.00	$2.05	$3.34	$4.15	$3.25	$3.10	$3.30
Channels, 3 to 15 in.	1.90@2.00	2.10	3.34	4.15	3.25	3.10	3.30
Angles, 3 to 16 in., ¼ in. thick.....	1.90@2.00	2.10	3.34	4.15	3.25	3.10	3.30
Tees, 3 in. and larger	1.90@2.00	2.10	3.34	4.15	3.35	3.10	3.30
Plates, ¼ in. thick and heavier.....	*1.60@1.90*	2.00	3.34	4.15	3.25	3.10	3.30

RIVETS—The following quotations are per 100 lb.:

STRUCTURAL

	Pittsburgh Mill	Warehouse: New York, Nov. 5	New York, One Yr. Ago	Chicago	St. Louis	San Francisco	Dallas
½ in.....	$2.40@2.50	$4.50	$3.75	$3.50	$3.65	$5.00	$4.75
CONE HEAD BOILER							
½ in.....	**$2.70@2.90**	$4.70	$3.85	$3.70	$4.20	$5.20	$5.00
⅝ and ¾.....	**2.85@3.05**	4.85	4.01	3.80	4.45	5.35	5.15
⅞ and 1.....	**3.10@3.30**	5.10	4.25	4.05	4.60	5.60	5.50

NAILS—The following quotations are per keg from warehouse:

	Pittsburgh Mill	Birmingham	Chicago	San Francisco	Dallas	St. Louis	Montreal
Wire.....	$2.65	$2.85	$3.15	*$3.40*	**$4.28**	**$2.93**	$4.95
Cut.....	2.90	2.90	.....	5.00	5.00	*3.13*	5.00

SHIP SPIKES—Current prices per 100 lb.:

In.	San Francisco: Galv.	San Francisco: Black	Seattle Black
½.....	$7.50	$5.75	$7.75
⅝.....	7.05	5.30	5.65
¾.....	6.90	5.15	5.50

Pittsburgh base in lots of 200 kegs or more, $3.25.

PREPARED ROOFINGS—Slate-surfaced roofing in rolls of 108 sq.ft. costs $2.00@$2.75 per roll to contractors in carload lots f.o.b. New York.

Single shingles, slate finish, cost $7.00 per square (sufficient to cover 100 sq.ft.) in carload lots, f.o.b. New York. Strip shingles (4 in 1) f.o.b. New York, in carload lots to contractors, $5.00 per square.

ROOFING MATERIALS—Prices f.o.b. New York, to contractors in carload lots:

Tar felt (14 lb. per square of 100 sq.ft.) per ton.....	$70.00
Asphalt roofing (in barrels), per ton.....	25.00
Asphalt felt, per ton.....	75.00

WINDOW GLASS—United inches, 25, bracket size 6x8 to 10x15, single thickness "AA," 82 per cent; "A," 87 per cent; "B," 88 per cent. Double thickness "AA," 82 per cent; "A," 88 per cent; "B," 89 per cent discount from jobbers list at New York warehouses.

SHEETS—Quotations are per 100 lb. in various cities from warehouse also the base quotations from mill:

Blue Annealed	Pittsburgh Large Mill Lots	St. Louis	Chicago	San Francisco	New York
No. 10.....	**$2.30@2.40**	$3.60	$3.50	**$3.85**	$3.89
No. 12.....	2.35@**2.45**	3.65	3.55	**3.90**	3.94
No. 14.....	2.40@**2.50**	3.70	3.60	**3.95**	3.99
No. 16.....	2.50@**2.60**	3.80	3.70	**4.05**	4.09
Black					
*Nos. 17 to 21.....	2.95@3.05	4.30	3.80	**4.60**	4.15
*Nos. 22 to 24.....	3.00@3.10	4.35	3.85	**4.65**	4.20
*No. 26.....	3.05@3.15	4.40	3.90	**4.70**	4.25
*No. 28.....	3.15@3.25	4.50	4.00	**4.80**	4.35
Galvanized					
No. 10 and 11.....	3.30@**3.40**	4.50	4.00	**4.90**	4.35
No. 12 to 14.....	3.40@**3.50**	4.60	4.10	**5.00**	4.45
No. 16.....	3.55@**3.65**	.....	.....	**5.15**	4.60
Nos. 17 to 21.....	3.70@**3.80**	4.90	4.40	**5.30**	4.75
Nos. 22 to 24.....	3.85@**3.95**	5.05	4.55	**5.45**	4.90
*Nos. 25 and 26.....	4.00@**4.10**	5.20	4.70	**5.60**	5.05
*No. 28.....	4.30@**4.40**	5.50	5.00	**5.90**	5.35

* For painted corrugated sheets add 30c. per 1,000 lb. for 5 to 28 gage; 25c. for 19 to 24 gages; for galvanized corrugated sheets add 15c., all gages.

LINSEED OIL—These prices are per gallon:

	New York: Nov. 5	New York: One Year Ago	Chicago: Nov. 5	Chicago: One Year Ago
Raw in barrels (5 bbl. lots)....	*$1.00½*	$1.08	*$1.01*	$1.05

E. N.-R. Prices of Construction Materials

WHITE AND RED LEAD—Per 100-lb. keg, base price, f.o.b. New York:

	Dry		In Oil	
	Nov. 5	1 Yr. Ago	Nov. 5	1 Yr. Ago
Red	$15.75	$15.25	$17.25	$16.75
White	15.75	15.25	15.75	15.25

Lumber

Prices wholesale, per M. ft. b.m., to dealers in carload lots, f.o.b.

San Francisco—Prices of rough Douglas fir No. 1 common, in carload lots to dealers at yards. To contractors, $2 per M. ft. additional.

	6-8 and 12 Ft.	10-16-18 and 20 Ft.	22 and 24 Ft.	25 to 32 Ft.
3x3 and 4	$26.00	$27.00	$28.00	$31.00
3x6 and 8	26.00	27.00	28.00	31.00
4x4-6 and 8	26.00	27.00	28.00	31.00
3x10 and 12	26.00	27.00	28.00	31.00
3x14	30.00	30.00	32.00	34.00
4x10 and 12	26.00	27.00	28.00	31.00
4x14	30.00	30.00	32.00	34.00

	24 Ft. and Under	25 to 32 Ft.	33 to 40 Ft.
6x10	$28.00	$30.00	$32.00
6x14	34.00	36.00	38.00
8x10	28.00	30.00	32.00
8x14	34.00	36.00	38.00

New York and Chicago—Wholesale prices to dealers of long leaf yellow pine.

	New York		Chicago	
	20 Ft. and Under	22-24 Ft.	20 Ft. and Under	22-24 Ft.
3x4 to 8x8	$48.00	$49.00	$42.50	$43.50
3x10 to 10x10	52.00	53.00	46.50	47.50
3x12 to 12x12	56.00	57.00	54.50*	55.50*
3x14 to 14x14	64.00	65.00	60.50†	61.50†
3x16 to 16x16	70.00	71.00	69.50	70.50

Wholesale price to dealers; to contractors, delivered from lighters or cars to job, $5@$10 additional. Short leaf pine costs $3 per M. less.
* 4x12 to 12x12. † 4x14 to 14x14.

Over 24 ft.—Add $1 for each additional 2 ft. in length up to 32 ft. for sizes 12x12 and under; for sizes over 12x12 add $2; for merchantable add $2 to sizes 10x10 and under.

Other Cities	8x8-In. x 20 Ft. and Under				12x12-In. 20 Ft. and Under	
	P.	Fir*	Hemlock	Spruce	P.	Fir*
Boston	$50.50	$48.00†	$51.00	$50.00	$60.00	$58.00†
Seattle	.....	25.00	.....	.....	.....	25.00
New Orleans	45.00	.....	.....	.....	35.00	.....
Baltimore	32.50	49.25	53.00	60.00	38.00	49.75
Cincinnati	37.00	73.00	73.00	85.00	48.00	77.00
Montreal	50.00	58.00	.....	.....	60.00	65.00
Los Angeles	.....	37.00	.....	.....	.....	38.00‖
Denver	.....	32.25	33.75	33.75	.....	33.75
Minneapolis	43.00	35.75	35.00	.....	44.50	35.75
Atlanta	31.00	.....	.....	.....	34.00	.....
Dallas	56.00	.....	.....	.....	60.00	.....
Kansas City, Mo.	41.50	40.75	.....	.....	54.50	.....
Birmingham	32.00	.....	.....	.....	34.00	.....
Philadelphia	56.00	34.00	37.00	40.00	67.00	34.00
Detroit	44.75	50.75	.....	.....	54.75	50.75
St. Louis	41.00	.....	.....	.....	53.00	.....

	1-In. Rough, 10 In. x 16 Ft. and Under			2-In. T. and Gr. 10 In. x 16 Ft.	
	P.	Fir*	Hemlock	P.	Fir*
Boston	$45.50	$42.00†	$45.00	$50.50	$48.00†
Seattle	.....	20.00	.....	.....	22.00
New Orleans	83.00	.....	.....	43.00	.....
Baltimore	55.00	44.00	44.00	34.00	50.00
Cincinnati	70.00	79.00	75.00	38.00	85.00
Montreal	56.00	50.00	45.00	45.00	45.00
Los Angeles	.....	37.00	.....	.....	.....
Denver	.....	32.75	29.25	.....	30.25
Minneapolis	43.00	35.75	34.75	38.00	34.25
Atlanta	18.00	.....	.....	28.00	.....
Dallas	52.25	.....	.....	56.00	.....
Kansas City, Mo.	49.50	39.25	.....	41.00	36.25
Birmingham	20.00	.....	.....	35.00	.....
Philadelphia	34.00	33.00	36.00	54.00	34.00
Detroit	37.25	37.50	.....	44.00	41.75
St. Louis	43.00	.....	.....	29.50	.....

Birmingham—Quotes carload lots, f.o.b. sidings; $4.00 additional per M. ft. to contractors.
Boston and Cincinnati—Prices to contractors in carload lots, f.o.b.
Denver—Quotes dealers price to contractors on large projects.
St. Louis—Wholesale price to contractors, f.o.b. cars, $2 per M.ft. additional.
Seattle—Price to contractors, delivered.
Dallas—Wholesale to contractors, $10 per M.ft. additional.
*Douglas fir. †Prime.

PILES—Prices per lineal foot, pine piles with bark on, f.o.b. New York.

Diameters	Points	Length	Barge	Rail
12 in. at butt	6 in.	30 to 50 ft.	$0.14½	$0.18½
12 in.—2 ft. from butt	6 in.	50 to 59 ft.	.19	.23½
12 in.—2 ft. from butt	6 in.	60 to 69 ft.	.21½	.25½
14 in.—2 ft. from butt	6 in.	50 to 69 ft.	.25½	.34
14 in.—2 ft. from butt	6 in.	70 to 79 ft.	.27½	.36½
14 in.—2 ft. from butt	5 in.	80 to 89 ft.	.35	.41

Miscellaneous

STEEL SHEETPILING—The following price is base per 100 lb. f.o.b. Pittsburgh, with a comparison of a month and a year ago:

Nov. 5	One Month Ago	One Year Ago
$2.25@$2.30	$2.25@$2.30	$1.95@2.05

WIRE ROPE—Discounts from list price on regular grades of bright and galvanized are as follows:

	Eastern Territory New York and East of Missouri River
Plow steel round strand rope	35%
Special steel round strand rope	30%
Cast steel round strand rope	20%
Round strand iron and iron tiller	5%
Galvanized steel rigging and guy rope	7½%
Galvanized iron rigging and guy rope	+12½%

California, Oregon, Nevada and Washington: Discount 5 points less than discount for Eastern territory.
Wyoming, New Mexico and Colorado: Discount 5 points less than discount for Eastern territory.
Arizona: Discount 10 points less than discount for Eastern territory.
Montana, Idaho and Utah: Discount 10 points less than discount for Eastern territory.
North Dakota, Nebraska, Kansas, Oklahoma and Texas: Discount 5 points less than discount for Eastern territory.

MANILA ROPE—For rope smaller than ¾-in. the price is ½ to 2c. extra; while for quantities amounting to less than 600 ft., there is an extra charge of 1c. The number of feet per pound for the various sizes is as follows: ¾-in., 8 ft.; ¾-in., 6; 1-in., 4½; 1-in., 3½; 1¼-in., 2 ft. 10 in.; 1½-in., 2 ft. 4 in. Following is price per pound for ¾-in. and larger, in 1200-ft. coils:

Boston	$0.19@.24	New Orleans	$0.24½
New York	.26	Los Angeles	.24½
Chicago	.24½	Seattle	.24
Minneapolis	.26½	St. Louis	.24½
San Francisco	.24	Montreal	.16
Atlanta	.32	Detroit	.26
Denver	.28	Baltimore	.18
Cincinnati	.21	Kansas City	.21½
Dallas	.31	Birmingham	.30@.31
Philadelphia	.26		

EXPLOSIVES—Price per pound of dynamite in small lots:

	Gelatin 40%	Gelatin 60%
New York	$0.27	$0.295
Boston	.225	.25
Kansas City	.2125	.2325
Seattle	.165	.19
Chicago	.22	.245
Minneapolis	.1917	.2123
St. Louis	.22	.245
Denver	.2025	.2275
Dallas	.225	.302
Los Angeles	.1875	.2125
Atlanta	.23	.255
Baltimore	.22	.23
Cincinnati	.22	.245
Montreal	.195	.235
Birmingham	.23	.255
New Orleans	.233	.26
San Francisco	.1625	.1925
Philadelphia	.215	.24

CHEMICALS—Water and sewage treatment chemicals, spot shipments in carload lots, f.o.b. works:

Sulphate of aluminum, in bags, per 100 lb	$1.40@1.45
Sulphate of copper, in bbl., per 100 lb	4.50@4.60
Soda ash, 58%, in bags, per 100 lb	1.25@1.55
Chlorine, liquid, tanks, per lb	.04@.04½
Hypochlorite of lime (bleaching powder) in drums, per 100 lb	1.90@2.00

FREIGHT RATES—On finished steel products in the Pittsburgh district, including plates, structural shapes, merchant steel, bars, pipe fittings, plain and galvanized wire nails, rivets, spikes, bolts, flat sheets (except planished), chains, etc., the following freight rates are effective in cents per 100 lb., in carloads of 36,000 lb.:

Atlanta	$0.58	Detroit	$0.29
Baltimore	.31	Kansas City	.735
Birmingham	.58	New Orleans	.67
Boston	.365	New York	.34
Buffalo	.265	Pacific Coast (all rail)	1.15*
Chicago	.34	Philadelphia	.32
Cincinnati	.29	St. Louis	.43
Cleveland	.19	St. Paul	.60
Denver	1.15*		

* Minimum carload, 50,000 lb., structural steel only; 80,000 lb., for other iron or steel products.